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MEMOIRS

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MEMOIRS

OF THE

BOSTON SOCIETY OF NATURAL HISTORY.

I. Volcanic Manifestations in New England: *being an enumeration of the principal Earthquakes from* 1638 *to* 1869. By William T. Brigham, A.M.

Read April 7th, 1869.

Although no recent or noteworthy manifestation of either seismic or volcanic force has made the present an especially appropriate time to review the records of the past, and collect the scattered and imperfect accounts of such seismic phenomena as have been noticed in New England in the comparatively short period covered by the observation of civilized nations, yet the steadily increasing interest in these studies will, perhaps, render useful a compilation of such facts as possess historical authenticity, which may serve as a basis for the observations which must be made in the field.

M. Alexis Perrey, the distinguished savant of Dijon, has published[1] in his series of local catalogues a tolerably complete list of the earthquakes which are said to have taken place in the central and eastern part of North America, but his work is not easily obtained. Professor Williams, also, in the Memoirs of the American Academy,[2] has collected much valuable material; and Professor Mallet's catalogue,[3] and many fragmentary scientific and historical papers contain nearly all the rest that is known of the surface indications of that power which has in ages long past done so much to mould the surface of New England.

Indian tradition gives us nothing of any value, for people in an uncivilized state do not note the paroxysmal changes of Nature, though the weather signs are often carefully observed. The early settlers in New England were men of little leisure, whose whole life was a battle against stubborn nature and sinful man, and the earthquake shock was a slight thing beside the abundant harvest of a cornfield, or the erection of the town stocks. Where the hand of the Lord led them they were willing to go, and where His hand was seen in the tremor of the mighty earth a record was made, but much as the record of some pest, or a great drought.

[1] Annales de la Societé d'Emulation des Vosges, t. VII, 2 cah. 1850.

[2] Memoirs of the American Academy of Arts and Sciences, vol. I, p. 260. 1785.

[3] Catalogue of Recorded Earthquakes, from 1606 B. C. to A. D. 1850. 1853.

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1638. Eighteen years after the Pilgrims landed at Plymouth they felt the first earthquake most of them had ever experienced. In Bradford's History is the following account:[1]

"This year (1638) aboute y^e 1. or 2. of June was a great & fearfull earthquake; it was in this place heard before it was felte. It came with a rumbling noyse, or low murmure like unto remoate thunder: it came from y^e norward, & pased southward. As y^e noyse aproched nerer, the earth begane to shake and came at length with that violence as caused platters, dishes, & such like things as stoode upon shelves, to clatter and fall downe; yea persons were afraid of y^e houses them selves. It so fell oute y^t at y^e same time diverse of y^e cheefe of this towne were mett together at one house, conferring with some of their friends that were upon their removall from y^e place, (as if y^e Lord would herby show y^e signs of his displeasure, in their shaking a peeces & removalls one from an other.) However it was very terrible for y^e time, and as y^e men were set talking in y^e house, some women & others were without y^e doors, and y^e earth shooke with y^t violence as they could not stand without catching hould of y^e posts & pails y^t stood next them; but y^e violence lasted not long. And about halfe an hower, or less, came an other noyse & shaking, but nether so loud nor strong as y^e former, but quickly passed over, and so it ceased. It was not only on y^e seacoast, but y^e Indeans felt it within land; and some ships that were upon y^e coast were shaken by it. So powerfull is y^e mighty hand of y^e Lord, as to make both the earth & sea to shake, and the mountaines to tremble before him when he pleases; and who can stay his hand? It was observed that y^e somers, for divers yeares togeather after this earthquake were not so hot & seasonable for y^e ripning of corne & other fruits as formerly; but more could & moyst, & subject to erly & untimely frosts, by which, many times, much Indean corne came not to maturitie; but whether this was any cause, I leave it to naturallists to judge."

Johnson, in his "Wonder-working Providence of Sion's Saviour in New England,"[2] describes the event as follows, and it will be noticed that his account adds several particulars to that of Bradford:

"This yeare, the first day of the Fourth Month, about two of the clock in the afternoone, the Lord caus'd a great and terrible Earthquake, which was general throughout all the English Plantations; the motion of the earth was such, that it caused divers men (that had never known an Earthquake before) being at work in the Fields, to cast downe their working tooles, and run with gastly, terrified lookes, to the next company they could meet withall; it came from the Westerne and uninhabited parts of this Wildernesse, and went the direct course."

Winthrop[3] fixes the time of day a little later and gives some vivid details. He says: "Between three and four in the afternoon, being clear, warm weather, the wind westerly, there was a great earthquake. It came with a noise like a continued thunder, or the rattling of coaches in London, but was presently gone. It was at Connecticut, at Narragansett, at Pascataquack, and all the parts round about. It shook the ships which rode in the harbor, and all the islands. The noise and the shakings continued about four minutes. The earth was unquiet twenty days after by times." Had there been observers farther to the north and west we might have learned more of the extent of territory shaken and the direction of the vibrations; but so little interest did natural phenomena excite in those days — unless indeed they could be connected with some poor witch, or used as weapons by the belligerent clergy, — that the scanty records remaining do not give much information of any value. One historian says the vibration seemed to come from the north, another from the west. There were two shocks, and the paroxysm ended in a series of feeble vibrations extending over twenty days.

[1] Page 366, Edition of the Massachusetts Historical Society.

[2] Chap. XII. Chap. V, p. 107, Poole's Edition.

[3] Vol. I, p. 265, Savage's Edition.

March 5, 1642–3, "At seven in the morning, it being the Lord's day, there was a great earthquake. It came with a rumbling noise like the former, but through the Lord's mercy it did no harm."[1] Governor Winthrop seems to be the only one of our early historians who notices this earthquake; neither Mallet nor Von Hoff include it in their catalogues. 1642-3.

From the town records of Newbury we have the following:

June 1*st*. "Being this day assembled to treat or consult together about the well ordering of the affairs of the towne, about one of the clocke in the afternoone, the sunn shining faire, it pleased God suddenly to raise a vehement earthquake, coming with a shrill clap of thunder, issuing, as is supposed, out of the east, which shook the earth and the foundations of the house in a very violent manner to our great amazement and wonder, wherefore taking notice of so great and strange a hand of God's providence, we were desirous of leaving it on record to the view of after ages, to the intent that all might take notice of Almighty God and feare his name."

A very slight shock was noticed in 1653 (October 29), but did not attract general notice, and is not mentioned by Mallet in his catalogue. Five years later occurred what is usually styled in the old histories, "a great earthquake." Morton says,[2] "This year there was a very great earthquake in New England," but no account of the day, hour or direction is given; perhaps it was April 4.[3] Von Hoff[4] enumerates this in his list, but gives no further particulars, referring simply to the Philosophical Transactions as his authority; Mallet does the same.[5] The same obscurity is over the "great" earthquake of January 31, 1660, which is referred to in Professor Williams's paper already quoted. 1653. 1658. 1660.

January 26, 1662, three violent shocks were felt in New England; chimneys were thrown down. *November* 6, another in the same place. 1662.

February 5, *N. S.* Morton tells us that "at the shutting in of the evening, there was a very great earthquake in New England, and the same night another, although something less than the former, and again on the seventh of the same month there was another about nine of the clock in the morning."[6] This earthquake was severer in Canada than in the plantations of Massachusetts Bay, and Charlevoix assures us that trees were uprooted, chasms opened, and the course of rivers changed.[7] Clavigero, in his "History of Mexico,"[8] declares that it overwhelmed a chain of mountains of freestone more than two hundred miles long, and changed that large tract into a plain; and this has a singular confirmation in the "Journal des Sçavans,"[9] where, in a review of the life of the celebrated Mary of the Incarnation, Superior of the Ursulines at Quebec, written by her son, is the following passage: 1663.

"Ce tremblement agita plus de quatrecent lieuës de païs. Tadoussac, Quebec, Sillery, les trois Rivieres, Montreal, les Hiroquois, l'Acadie, et la Nouvelle Holland en ressentirent les secousses * * *. Les effets en furent si terrible et si prodigieux, qu'on auroit de la peine à les lire même dans ce Livre et beaucoup plus à les croire, s'ils n'étoient arrivez de nos jours, et s'ils n'avoient pour temoins une infinité d'habitans de tous ces

[1] Winthrop's History of New England, vol. II, edition of 1853, p. 112.

[2] Memorial, p. 276.

[3] Canadian Naturalist and Geologist, vol. V, p. 369.

[4] Chronik der Erdbeben und Vulcan-ausbrüche, I, p. 307.

[5] Philosophical Transactions, vol. L, p. 9.

[6] Morton's Memorial, p. 289.

[7] Charlevoix Histoire de la Nouvelle France. A mountain was thrown on to the Isle aux Coudres. See pp. 93, 95, vol. I, English Translation. Paul Dudley gives the year 1662. Philosophical Transactions, XXXIX, p. 64. See Von Hoff Geschichte der Erdoberfläche, t. II, p. 542.

[8] I have been unable to find the passage referred to.

[9] Vol. VII, May, 1678, p. 103.

païs qui vivent encore. L'on voyoit des montagnes s'entrechoquer, d'autres se jettoient dans le grand Fleuve de Saint Laurent; quelques autres se sont enfoncées dans la terre. Il y en a eu qui se sont detachées de leurs fondemens, et qui ont avancé plus de cent brasses dans le Fleuve portant et retenant leurs arbres et leur verdure. Les Montagnes des deux côtez se sont perduës et égalées aux Campagnes voisines plus d'une lieuë sur le Fleuve, et il y a un espace de plus de cent lieuës tout rempli de rochers et de montagnes qui s'est tellement applani, qu'il fait aujourd'hui une grande plaine aussi égale que si elle avoit été dressé au niveau. On voit depuis ce tems-la des Montagnes où il n'y en avoit jamais eu; des Rivieres où il y avoit auparavant des Forêts, et on trouve des Lacs et des Fleuves où l'on voyait des Montagnes inaccessibles."

No contradiction followed the publication of this remarkable statement in Paris. The substance of Charlevoix's account is as follows: About half past five in the evening, the heavens being very serene, there was suddenly heard a roar, like that of a great fire. Immediately the buildings were shaken violently, and doors opened and shut of themselves with a great slamming. Bells rung without being touched, and walls split asunder, while the floors separated and fell down. The fields were raised "like precipices," and mountains seemed to be moving out of their place. Animals were terrified and uttered strange cries. For nearly half an hour the trembling lasted, a most unusual time, but it began to abate in a quarter of an hour after it first began. The same evening, about eight o'clock, there was another equally violent shock, and within half an hour two others less violent. The next day, "about three hours from the morning, there was a violent shock, which lasted a long time; and the next night some counted thirty-two shocks; of which many were violent." Nor did these earthquakes cease until the July following.[1] New England and New York were shaken, as well as Canada, but in a less degree, and the whole territory convulsed, so far as can be learned, extended nearly three hundred miles from east to west, and half as many from north to south. Sometimes the shocks were sudden, at other times they came on gradually; some seemed to be vertical, others undulatory. Springs and brooks were dried up, or became sulphurous; and some had their channel so completely altered as hardly to be recognized. Between Tadoussac and Quebec "two mountains" were shaken into the St. Lawrence, and perhaps from a similar accession of material the Island Aux Coudres became larger than it was before. The course of all these waves was from the northwest when felt in New England, and the centre of disturbance was not far from the ancient volcano of Montreal. On the shores of Massachusetts Bay, houses were shaken so that pewter fell from the shelves, and the tops of several chimneys were broken; but as many of the latter were of rough stone, they were the more easily overthrown.[2]

From the Newbury record is the following: "January 26th. There was an earthquake at the shutting in of the evening." One of the greatest in New England; and on February 5th another. The first shock continued about half an hour. On the same day, at evening, another, and they did not cease till July following.[3]

1665. *February* 24, 1665. In the neighborhood of Tadoussac and La Malbaye, in Canada, violent shocks were felt, but they are hardly noticed in any of the New England chronicles. Lallemant is the authority for this, and also for an earthquake on

[1] Memoirs of the American Academy, vol. 1, p. 264.

[2] See also Frezier's Voyage, pp. 210, 211. Also MacGregor's Travels in America.

[3] Coffin's History of Newbury, p. 66. Probably the date February 5, is simply a mistake from the change of style. February 5, N. S., is the same as January 26, O. S.

October 15th of the same year, at 9^h 30′ P.M., preceded by a noise louder than that of two hundred pieces of artillery, and lasting "about the time of a Miserere."[1]

Earthquakes are mentioned in the years 1668, 1669, 1670 and 1706, but no account has been preserved.[2] Neither Mallet nor Von Hoff mention them. Dr. Mather simply speaks of those occurring in the last two years, and there was one on *January* 8, 1720, but all were so slight as to escape general notice, and no particulars have been recorded. 1720.

November 8, 1727. About forty minutes past ten o'clock in the evening, during a perfect calm, clear air and serene sky, a heavy rumbling noise was heard. At first far off, it grew louder and in about thirty seconds the shock came. Houses shook and rocked as if falling to pieces. Pewter and china were thrown from their shelves. Stone walls and chimneys were shaken down, and it was difficult for men to stand up. The ground seemed to rise and fall as the vibration passed. The shock commenced about half a minute from the time the noise was first heard, rose to its maximum in about a minute, and then decreased in half a minute. The direction was from northwest to southeast. At Newbury, and about the mouth of the Merrimack River, the shock was most violent. Reverend Benjamin Colman, D.D., says:[3] "There the earth opened and threw up many cart-loads of a fine sand and ashes, mixed with some small remains of sulphur; but so small that taking up some of it in my fingers and dropping it into a chaffing-dish of bright coals, in a dark place, once in three times the blue flame of the sulphur would plainly arise and give a small scent, and but a small one. By this it seems evident that it was a sulphurous blast which burst open the ground and threw up the calcined bituminous earth." In the account Dr. Dudley sent to the Royal Society,[4] the sulphurous smell is spoken of, and he says: "Persons of credit do also affirm that just before, or at the time of the earthquake, they perceived flashes of light." 1727.

An account written by Stephen Jaques is as follows:[5]

"On the twenty-ninth day of October, between ten and eleven, it being sabath day night, there was a terabel earthquake. The like was never known in this land. It came with a dreadful roreing, as if it was thunder, and then a pounce like grate guns two or three times close one after another. It shook down bricks from y^e^ tops of abundance of chimnies, some allmost all the heads. . . . All that was about y^e^ houses trembled, beds shook, some cellar walls fell partly down. Benjamins Plumer's stone without his dore fell into his cellar. Stone wals fell in a hundred plasis. Most peopel gat up in a moment. It came very often all y^e^ night aftar, and it was heard two or three times some days and nights, and on the sabath day night on y^e^ twenty-fourth of December following, between ten and eleven, it was very loud, as any time except y^e^ first, and twice that night aftar but not so loud. The first night it broke out in more than ten places in y^e^ town in y^e^ clay low land, blowing up y^e^ sand, sum more, sum less. In one place near Spring Island it blew out, as was judged twenty loads, and when it was cast on coals in y^e^ night, it burnt like brimstone."

Probably the smell of brimstone noticed was purely imaginary, and the earth or sand thrown out was due to the agency of water pent up beneath the clay soil, since, as will be seen below, the water which issued with it continued to flow for several days.

[1] Relation de ce qui s'est passé de plus remarquables aux missions des Péres de la Compagnie de Jésus en la Nouvelle France en 1661 et 1665. Par Jérome Lallemant. p. 115 et suiv.

[2] Philosophical Transactions, no. 437, vol. XXXIX, p. 61.

[3] Philosophical Transactions, no. 409, vol. XXXVI, p. 125.

[4] *Loc. cit.* no. 137, vol. XXXIX, p. 72. He adds (p. 69): "Our house-dogs were also sensible and affected with the earthquake; some of them barking, others howling and making strange and unusual noises."

[5] Coffin's History of Newbury, p. 198.

Mr. Henry Sewall, of Newbury, wrote to his kinsman, Judge Samuel Sewall, of Boston, the following letter:[1]

NEWBURY, *November* 21, 1727.

"Honored sir:

Thro' God's goodness to us we are all well, and have been preserved at the time of the late great and terrible earthquake. We were sitting by the fire and about half after ten at night our house shook and trembled as if it would have fallen to pieces. Being affrighted we ran out of doors, when we found the ground did tremble, and we were in great fear of being swallowed up alive; but God preserved us, and did not suffer it to break out, till it got forty or fifty rods from the house, where it brake the ground in the common near a place called Spring island, and there is from sixteen to twenty loads of fine sand thrown out where the ground broke, and several days after the water boiled out like a spring, but is now dry, and the ground closed up again. I have sent some of the sand that you may see it. Our house kept shaking about three minutes."

It is said that several springs of water, and wells that were never known to be dry or frozen, were sunk far down into the earth; and while some were dried up, others had their temperature so altered as to freeze in moderate weather. Some had their water improved, but others were made permanently bad. Some firm land became quagmire, and marshes were dried up. Several phenomena were observed a few days previous to this earthquake, of a nature often observed preceding earthquakes in other countries, especially in Campania. One observer, the Rev. Mr. Allin, of Brookline, says: "Three days before the earthquake there was perceived an ill-stinking smell in the water of several wells. Not thinking of the proper cause, some searched their wells, but found nothing that might thus infect them. The scent was so strong and offensive that for about eight or ten days they entirely omitted using it. In the deepest of these wells, which was about thirty-six feet, the water was turned to a brimstone color, but had nothing of the smell, and was thick like puddle water."

Mr. Dudley, in the account already referred to, says:[2] "A neighbor of mine that had a well thirty-six feet deep, about three days before the earthquake, was surprised to find his water, that used to be very sweet and limpid, stink to that degree that they could make no use of it, nor scarce bear the house when it was brought in; and imagining that some carrion was got into the well, he searched the bottom, but found it clear and good, though the color of the water was turned wheyish, or pale. In about seven days after the earthquake the water began to mend; and in three days more it returned to its former sweetness and color." Several wells dried up just before the earthquake, and were afterwards full again.

The extent of this shock seems to have been from the Kennebeck to the Delaware, although in both of these places the shock was slight. It was felt by vessels at sea off the coast, and also at the extreme western settlements, but its true extent northwest and southeast we have no means of knowing. In "Smith's Journal" it is mentioned as a noteworthy consequence of this uncommon alarm, that a revival of religion took place; "forty out of one hundred and twenty-four" were the fruits of it in Rev. Mr. Emerson's parish in Portsmouth, which was in the most disturbed district.

Several shocks were felt in northern New England for some months after this, but they were slight and of short duration. It will be remembered that on the eighteenth of

[1] Coffin's History of Newbury, p. 198.

[2] Philosophical Transactions, no. 437, vol. XXXIX, p. 72.

November, the city of Tabriz, in Persia, was destroyed by an earthquake, and seventy-seven thousand people perished.[1]

The Rev. Matthias Plant, the minister at Newbury, kept a record of the shocks felt from 1727 to 1741, and from this church record wrote an account to England, which was published,[2] and the essential part is here reprinted. The dates are all in old style:

October 29, 1727, being the Lord's-Day, about forty minutes past ten the same evening, there came a great rumbling noise; but before the noise was heard, or shock perceived, our bricks upon the hearth rose up about three quarters of a foot; and seemed to fall down and loll the other way, which was in half a minute attended with the noise or burst. The tops of our chimneys, stone fences were thrown down; and in some places (in the lower grounds, about three miles from my house) the earth opened and threw out some hundred loads of earth of a different color from that near the surface, something darker than your white marl in England. . . . It continued roaring, bursting and shocking our houses all that night. Though the first was much the loudest and most terrible, yet eight more that came that night were loud, and roared like a cannon at a distance. It continued roaring and bursting twelve times in a day and night, until Thursday in the said week, and then was not so frequent; but upon Friday in the evening, and about midnight, and about break of day upon Saturday, three very loud roarings; we had the roaring noise upon Saturday, Sunday, Monday, about ten in the morning, although much abated in the noise.

November 7 being Tuesday, about eleven it roared very loud, and gave our houses a great shock; and continued shocking from three times to six every day and night, until the twelfth of November, when it was heard twice in one hour in the afternoon, from 3^h 30′ to 4^h 30′.

November 13. Two hours before daybreak the roaring was loud, and shook the houses. Upon Wednesday following, 2^h 30′ in the afternoon, there was a roaring, but not so loud. The noise and shocks continued five, six, to ten times a week, until the seventeenth of December following; and then about half an hour past ten in the evening, it roared very loud and shook our houses very much; another shock the next morning about four o'clock, much abated.

January 3, 1727–28. About nine at night, an easy shock.

January 6. There were five shocks attended with the roaring, from about nine at night to four on Sunday morning; and some people told me, that lived in the low grounds, that for the space of about half an hour it continually kept roaring every half minute or minute.

Wednesday, January 24. About half an hour after nine at night it roared exceedingly loud, and was followed in half a minute with roaring much abated in the noise.

January 28, 6^h 30′ A.M., another easy shock, and another about ten the same morning, easy. On the same night, about 1^h A.M., a loud roaring and shock.

January 29. I heard it twice, though easy, that day.

January 30. About two in the afternoon, there was a very great roaring, equal to any but the first for terror; it shook our houses so as that many people were afraid of their falling down; pewter, etc., was shook off our dressers; . . . . the lead windows in the church rattled to such a degree, as that I thought they would all be broke. And there was another shock the same day, about an hour and half after, though much abated.

February 21. About half an hour past twelve, A.M., a considerable loud roaring with a shock.

February 29. Such another.

March 17. About three in the morning an easy shock.

March 19. At 1^h 40′ P.M., a small noise; at nine the same night a small noise with a shock.

April 28, 1728. At 5^h P.M., a small noise but perceivable.

May 12. About 9^h 40′ a long and loud roaring, and shook the houses.

May 17. About 8^h P.M., a long and loud roaring shook our houses.

May 22. Several small roarings in the morning; but about ten o'clock the same morning, long and loud, and shook our houses.

June 6 and 8. About three o'clock in each morning, a long and loud roaring.

[1] At Salem, Nov. 4, a meeting was held in the house of the first parish on account of the "terrible earthquake." Many attended. Mr. Fisk preached from I Peter, IV, 17, 18. Felt's Annals of Salem, p. 385.

A fast was appointed on the 21st of December on the same account. *Ibid.* p. 386.

[2] Philosophical Transactions, no. 162, vol. XLII, p. 33.

June 11. Nine in the morning a small noise.

July 3. About two in the morning.

July 23. About break of day, very loud and long; shook our houses. Besides these times I have mentioned, it has been often heard by me, but the noise was small, so forbore to set them down.

March 19, 1728–9. Betwixt two and three P.M., it was loud and long, shook our houses, being repeated twice in an instant; and this was the longest and loudest roaring, and the greatest shock that I ever heard, the first excepted, and that upon the thirtieth of January. We had several small shocks in this interim.

September 8, 1729. About 3^{h} 30′ [P.M.?] it was loud and long.

September 29. About 4^{h} 30′ P.M., loud and long.

October 29. I heard it twice this night. One of the times was about the same time of night the first shock was [10^{h} 40′ A.M.].

November 14. About eight in the morning loud and long; attended with two bursts like unto two sudden claps of thunder; shook our houses.

November 27. About eight in the evening a very great roaring and a great shock. It was heard at Ipswich, about fourteen miles distant.

February 8, 1729–30. About eight in the evening a small shock, about midnight loud and long, and gave our houses a great shock.

February 26. About 1^{h} 45′ A.M., the noise was repeated twice in one minute; the first was loud and long, and shook our houses equal to any but the first shock; the second noise was low and seemingly at a distance.

April 12, 1730. About eight in the evening a very loud and long noise, and a great shock.

July 28. About 9^{h} A.M., a sudden and loud roaring, and shock.

August 15. About 8^{h} A.M., a shock of the earthquake, twice repeated in a moment of time.

November 6. It was loud and long, and gave my house a jar.

November 14. About 9^{h} A.M., a small noise and rumbling; no shock.

November 25. About 8^{h} 20′ P.M., a loud and long roaring, and gave my house a considerable shock.

December 6. About 10^{h} 45′ P.M., it was loud and roared long, and made our houses jar.

December 11. About 6^{h} 45′ P. M., there was a small burst, but shaked my house.

December 12. About 10^{h} 30′ P.M., the earthquake did very much shake our houses, without any noise or roaring, more than ever before, the first time excepted. It was felt at *Boston*, forty miles, at *Piscataqua*, twenty-two miles, almost equal to what it was with us.

January 7, 1730–1. About seven at night it was loud and long, shook our houses.

January 11. About midnight loud and long, shook our houses.

March 7. About five in the evening we heard the noise, but no shock.

May 28, 1731. About nine in the morning I heard the noise of the earthquake very distinctly, but could not perceive that it shook.

July 5. About sunrise it was loud and long, shook our houses.

August 21. Nine o'clock in the evening the noise was small and short.

October 1. About eleven at night loud and long, shook our houses.

February 7, 1731–2. About seven at night a great shock, shook our houses.

September 5, 1732. About noon we had a severe shock, which was perceived at *Boston* and *Piscataqua*, but attended with little or no noise. The same earthquake was heard at Montreal, in Canada, at the same time and about the same hour of the day, and did damage to one hundred and eighty-five houses, killed seven persons, and hurt five others; and it was heard there several times afterwards, only in the night, as the newspapers give us this account. [See below for the extent of this shock.]

December 30. In the morning we had a shock, and it had been heard by some people several times within three weeks before.

March 1. A loud and long noise of it.

October 19, 1733. A loud and long noise about midnight.

January 16, 1733–4. About 10^{h} 20′ P.M., a loud and long roaring.

June 29, 1734. About 3^{h} 15′ P.M., there was somewhat of a noise of it.

October 9. About 10^{h} 20′ A.M., a small shock.

November 11 or 12, for it was about midnight, we had the loudest noise and greatest shock, except the first; it was long, very awful and terrible.

November 16. About six in the morning there was a small shock.

February 2, 1735–6. About a quarter of an hour before six in the evening there was a pretty loud noise and shock.

March 21. About half an hour past ten in the morning it was somewhat loud.

July 13, 1736. About 9^h 45′ A.M., the noise of it was loud.

October 1. About 1^h 30′ A.M., it was long and loud, and a great shock twice repeated in an instant.

November 12. About two in the morning there was a shock with the noise, and about six the same morning, it was something louder.

February 6, 1736–7. About 4^h 15′ P.M., we had a considerable shock.

September 9, 1737. About 10^h 20′ A.M., it was very loud and long, and shook our houses very much.

December 7. A little before eleven in the night the ground shook very much, but [we] heard no noise. Upon the same seventh of December, at *New York*, they had three severe shocks of an earthquake in the night; it threw down there some chimneys, and made the bells to toll so as to be heard. At the same time the said shock and noise was felt and heard in many other places.

August 2, 1739.[1] We had a great shock; it made my house shake much, and the windows jar. It was about half an hour past two in the morning; I think I never heard but two other louder or longer, or greater.

December 14, 1740. About 6^h 35′ A.M., there was heard a pretty loud noise of the earthquake.

January 18, 1740–1. About 4^h A.M., there was heard the noise of the earthquake.

January 25, 1740–1. About ten minutes before four in the afternoon, there was a shock of the earthquake with a loud rumbling noise. This is the last that has been heard (and I pray God I may never hear any more such, and so long). I have omitted to set down some that were small, or such as I did not hear myself; I was very exact to the time, so that what account I have sent you is most certainly true. * * * And although the first night was the most terrible, as the surprise was sudden; yet there never happened one shock amongst us but what occasioned some alteration at that time in every person's countenance or constitution; and which way soever any person's face happened to be, that way the noise of the earthquake appeared to him. * * * These frequent repetitions of the roaring and shocks of the earthquake were upon Merrimack River, and seldom extended above seven or eight miles distance from, or twenty or thirty up the said river, those instances only excepted which I have mentioned in the relation; and the first shock of it was greater with us than anywhere else in New England; and the tops of chimneys and stone fences were thrown down only in these parts.[2]

It is said that on the Tuesday preceding September 15, 1728, a shock was felt at Newbury, at four o'clock A.M., preceded by a noise like thunder,[3] but Mr. Plant does not mention it.

January 30, 1728, at 2^h P.M. a distinct shock was felt at Boston, but no damage was done. From November 9, 1727 to August 2, 1728, there were several slight shocks felt in New England. 1728.

September 15, 1732. A violent earthquake was felt in Canada, which did considerable damage at Montreal, as stated in the preceding list. It came at eleven o'clock A.M., and was attended with a rumbling noise. A clock was stopped at Annapolis, Maryland, although the shock was slightly felt at Boston.[4] In June, of the next year, on the fourteenth, according to some authorities, it is said a shock was felt at Annapolis, but there is no certainty that it took place. 1732.

On *February* 16, 1737, at 4^h 30′ P.M., shocks were felt at Boston. *December* 17, shortly before eleven o'clock at night, shocks were felt at New York (three during the night) and Boston, severe enough to throw down several chimneys in the former city, as described by Mr. Plant. In *October* or *November* of the same year a very 1737.

[1] Reverend Samuel Phillips, of Andover, notes in an almanac, under this date; "The night following was an earthquake y^e noise long and loud." Felt's Annals of Salem.

[2] This letter was read February 21, 1742.

[3] Philosophical Transactions, vol. XXXVI, p. 127.

[4] Philosophical Transactions, no. 429, vol. XXXVIII, p. 120.

slight shock was felt in Boston,[1] but it is only referred to as happening about seventeen years before the great earthquake of 1755.

1741. *December* 6, 1741, a small earthquake was felt at Boston, Dedham, Walpole, and other towns about eight o'clock in the morning.[2]

On Sunday, *June* 13, 1741, at 10^h 35′ A.M., a very noisy earthquake took place, although the shock was not very great. The day was bright and hot, and the barometer fell slightly (two lines) in the morning. There had been no rain since the twenty-third of May, and the whole month was dry and hot. Much lightning was observed during the latter part of the month. At the time of the earthquake the barometer, as observed by Professor Winthrop, stood at 29.94.[3]

1744. On *May* 16, 1744, a considerable vibration felt at Quebec, Canada. *June* 3, a slight shock at Cambridge, Massachusetts. *December* 23, a small earthquake was felt about Newbury at noon.[4]

1746. *February* 2, 1746, a shock was felt by some at Boston, between nine and ten in the evening. A very remarkable aurora borealis was observed a month later.[5]

1755. The year of the great Lisbon earthquake was long remembered in New England, and careful accounts were prepared at the time by Professor John Winthrop, of Cambridge, and published both in this country and in England.[6] The shock which had destroyed the city of Lisbon, with so many of her inhabitants, was felt from Iceland on the north to Morocco on the south, from Bohemia to the West Indies. After an interval of only eighteen days, and during this time slight shocks had been felt in Europe, as if the vibration of the earth's crust still continued from the first great impulse, New England and the neighboring parts of America were shaken. On Tuesday, *November* 18, 1755, at 4^h 11′ 35″,7 after a perfectly calm night, with the moon, which was near (thirty-six hours) the full, shining brightly, the shock came. Like the other earthquakes of New England, this began with a roaring noise from the northwest, like distant thunder. A man who was on the road at the time, heard the noise and recognized its nature as it grew louder, and in about a minute he felt the shock, which resembled a long rolling sea; and the swell was so great that he was obliged to run and catch hold of something to prevent being thrown down. The tops of two trees near him, one twenty-five and the other thirty feet high, waved, he thought, ten feet. This motion was repeated, and then came a smaller one, and it was supposed that the shock was passed. "But instantly," Winthrop says, "without a moment's intermission, the shock came on with redoubled noise and violence, though the species of it was altered to a tremor, or quick horizontal vibratory motion, with sudden jerks and wrenches. The bed on which I lay was now tossed from side to side; the whole house was prodigiously agitated; the windows rattled, the beams cracked, as if all would presently be shaken to pieces. When this had continued about two minutes it began to abate, and gradually kept decreasing, as if it would soon be over; however, before it had quite ceased, there was a little revival of the trembling and noise, though no ways comparable to what had been before, but this presently decreased, till all, by degrees, became still

[1] Philosophical Transactions, vol. XLIX (pt. I), p. 413.
[2] Silliman's Journal, vol. XL, p. 204.
[3] Philosophical Transactions, vol. L (pt. I), p. 14.
[4] Silliman's Journal, vol. XL, p. 205.
[5] *Loc. cit.*
[6] Philosophical Transactions, vol. L, (pt. I, 1757), p. 1, *et seq.*
[7] Prof. Winthrop had regulated both his clock and watch the previous noon, and a tall glass tube that he had enclosed in the clock case for safety was thrown against the pendulum at the first shock, stopping the clock.

and quiet. Thus ended this great shock. It was followed by another about an hour and a quarter after, viz., at 5^h 29′. This, though comparatively small, was very generally perceived, both as to its noise and trembling, by those who were awake. On the Saturday evening following (*November* 22), at twenty-seven minutes after eight, there was a third, more considerable than the second, but not to be compared with the first. And on Friday, *December* 19, in the evening exactly at ten o'clock, there was a fourth shock, much smaller than either of the former, though like them, preceded by the peculiar noise of an earthquake. The whole lasted but a few seconds; but the jarring was great enough to cause the window shutters and door of the room in which I then was, to clatter. The sky was perfectly clear. * * * These four are the only shocks that I have been sensible of, from the eighteenth of November last, to this date (*January* 10, 1756); though more are said to have been felt in other parts of the country to the northward of us." On the day of the first shock, nine hours after it was felt at Cambridge, or about two o'clock in the afternoon, the sea withdrew from the harbor of St. Martin's in the West Indies, leaving vessels dry, and fish on banks where the depth of water was usually three or four fathoms. It would seem from this, and from the observation of the direction of the sound, that the earthquake vibrated from northwest to southeast, and of course its secondary impulses were transverse to this primary line. As it moved much slower than sound, as was shown by the fact that it was heard nearly a minute before the motion was felt, it would not be unreasonable to suppose that as sound would require two hours and a quarter to go such a distance, the earthquake wave impeded by ocean currents, may have required nine hours to send its secondary waves to the harbor of St. Martin's.

How far did the shock extend? Professor Winthrop says:[1] "By the best information that I can procure, the limit toward the southwest was Chesapeake Bay, in Maryland, the shock having been felt on the eastern side of that bay and not on the western. For the other limit towards the northeast, we are informed that the earthquake was felt at Annapolis Royal, in Nova Scotia, though in a much less degree than with us. It shook off a few bricks from the tops of some chimneys, but was not perceived by vessels on the water." It was not felt north of Halifax, but the army at Lake George perceived a slight trembling; and in the Atlantic, seventy leagues to the east of Cape Ann, the people on board a vessel supposed they had run aground, so violent was the shock, but their lead showed fifty fathoms of water. If we consider the tidal wave at the West Indies a result as well as a consequent of this New England shock, we shall have a line nearly nineteen hundred miles long, and the shortest diameter of the shaken region would be almost five hundred miles, but the intensity of vibration rapidly diminished away from the central line.

If all previously recorded earthquakes in New England were unimportant, and sent, as Morton says, for "gentle warnings unto us to shake us out of our earthly-mindedness, spiritual security and other sins, lest the Lord do come against us with judgment of this kind in the sorest and worst sort of them," that of 1755 was one of great severity. In Boston, the damage done was considerable, as is shown by Professor Winthrop.[2] "Besides the throwing down of glass, pewter, and other movables in the houses, many chimneys

[1] *Loc. cit.* p. 9.

[2] *Loc. cit.* p. 11.

were levelled with the roofs of the houses, and many more shattered and thrown down in part. Some were broken off several feet below the top, and, by the suddenness and violence of the jerks, canted horizontally an inch or two over, so as to stand very dangerously. Some others were twisted or turned round in part. The roofs of some houses were quite broken in by the fall of chimneys; and the gable ends of some brick buildings thrown down, and many were cracked. The vane upon the public market house was thrown down; the wooden spindle which supported it, about five inches in diameter, and which had stood the most violent gusts of wind, being snapped off. A new vane upon one of the churches was bent at its spindle, two or three points of the compass; and another at Springfield was bent to a right angle. A distiller's cistern, made of plank, almost new, and very strong put together, was burst to pieces by the agitation of the liquor in it; which was thrown out with such force as to break down one whole side of the shed that defended the cistern from the weather." Another account says "that in some places, especially on the low, loose ground made by encroachments on the harbor, the streets are almost covered with the bricks that have fallen."[1]

All through the country stone fences were thrown down, but especially on a line extending from Montreal to Boston. New springs were opened and old ones dried up. At Pembroke, Scituate and Lancaster, in Massachusetts, chasms opened in the earth; and at Pembroke "there were four or five of them, out of some of which water issued, and many cart loads of a fine, whitish and compressible sand were spewed." In the harbor the shock was felt by those in vessels as if they were beating upon the bottom; and immediately after the earthquake large numbers of fish came to the surface, some dead and others dying. This was doubtless due to the unusual disengagement of carburetted and sulphuretted gases from the bottom, by the shock. Several slight shocks were felt for several months after this all over the country.

The motion was much greater in the upper parts of a house than in the lower. A key was thrown from a shelf in a southwest direction, although it could have fallen any other way except southeast. Some bricks which fell from the top of a chimney, a height of thirty-two feet, were found thirty feet from the base of a perpendicular. The barometer and thermometer underwent no change during the time of the earthquake.

Mr. John Hyde says:[2] "Many chimneys, I conjecture (from observation) not much less than an hundred, are levelled with the roofs of the houses; many more, I imagine not fewer than twelve or fifteen hundred, are shattered and thrown down in part."

November 21 and *December* 19 slight shocks at Boston.

1756. *January* 2, 1756, a shock was felt in Boston, according to Keferstein.[3]

November 16, 1756, about four o'clock in the morning a small earthquake, which seemed not to last above two seconds. All I perceived was the rattling of the window shutters by my bed's head. The sky was covered. Little or no wind. The weather moderate. It was more sensibly perceived in other towns" [than Cambridge].[4]

December 1, 10h P. M., a slight shock.[5]

1757. *July* 8, 1757, at 2h 15′ P. M., a considerable shaking was felt at Boston, but it was of short duration.[6]

[1] Philosophical Transactions, vol. XLIX, (pt. 1), p. 441.
[2] *Loc. cit.*
[3] Malle's Catalogue.
[4] Observations of Professor Winthrop in Silliman's Journal, vol. XL, p. 206.
[5] *Loc. cit.*
[6] *Loc. cit.*

April 24, 1758, 9^h 30′ P.M., a trembling lasting thirty seconds and preceded by subterranean noises which increased by degrees, was felt at Annapolis, Maryland, and more feebly in Pennsylvania.[1]

February 2, 1758, a slight shock at Boston. The date 1759 is given in the Annual Register, quoted by Mallet.[2] 1758.

February 3, 1760, slight in New England.[3]

November 9, at Boston a slight tremor.[4] More severe in the neighborhood. 1760.

February, at Boston, no mensual date given.[5]

March 12 and 16,[6] in New England, especially at Boston, more violent on the former date. "Salem, March 12. We were, last night, about quarter past two o'clock, roused out of our beds by an astonishing earthquake, much such as that five years ago, only that was a more terrible jar and this was undulating."[7] The later date is perhaps a mistake. Professor Williams does not mention it, but describes the earthquake of the 12th as slight, commencing at 2^h 30′ A.M., with a slight shock, followed after a slight pause by another more violent. The weather was moderate, perfectly calm, and a whitish fog covered the horizon all around. It was felt in all the neighboring States.[8] 1761.

November 1, 8^h P.M., a shock was felt through Massachusetts and in New Hampshire. It was preceded by the usual rumbling noise, and its course was from northwest to southeast.[9]

October 30, 1763, 4^h 15′ P.M., a shock was felt in Philadelphia which interrupted services in the churches, but did no damage. Our only authority for this, however, is a newspaper report.[10]

February 2, 1766. In Massachusetts and Rhode Island, and other parts of New England, accompanied by a remarkable meteor.[11] 1766.

June 14, in Essex County, Massachusetts.

August 25, at Newport, Rhode Island, a violent shock lasting twenty-five minutes.

December 17, 6^h 48′ at Portsmouth, New Hampshire, a violent shock.[12] An earthquake reported on February 2, 1776, did not occur.

November 29, 1783, about 10^h 50′ P.M., an earthquake was felt from New Hampshire to Pennsylvania. It was slight, and at Boston and in New England generally, only one shock was felt, and that from north to south and continuing about one minute. At New York three shocks were felt about 9^h, 11^h P.M., and 2^h A.M. At Philadelphia, one about 9^h P.M., and another about 2^h A.M.[13] 1783.

January 2, 1785, 7^h 15′ A.M., a shock was felt at Cambridge, Massachusetts, and at the same time at Baltimore, Maryland.[14] 1785.

November 29, 1786, 4^h P.M., at Cambridge.[15] 1786.

February 25, 1787, 1^h A.M., again at Cambridge.[16] 1787.

[1] Collection Académique, t. VI, p. 688.

[2] Doddesley's Annual Register, vol. II, p. 88.

[3] Annual Register, vol. III, p. 92.

[4] Gazette de France, Jan. 31, 1761.

[5] Journal Historique, Juillet, 1761, p. 65.

[6] Annual Register, vol. IV, p. 117.

[7] Smith's Journal quoted in Felt's Annals of Salem, p. 457.

[8] Memoirs of the American Academy, vol. I, p. 278.

[9] *Loc. cit.* p. 279.

[10] Gazette de France, 9 Janvier, 1764.

[11] Silliman's Journal, vol. XXXIX, p. 336.

[12] Annual Register, vol. X, p. 52. The Gazette de France, 6 Mars, 1767, gives the date as 13, and the time 6^h 40′ P.M.

[13] Professor Williams, *loc. cit.* p. 279. The Gazette de Leyde, Jan. 23, 1784, gives the time of the shocks at New York as 10^h 30′ P.M., and 2^h 30′ A.M.

[14] Éphémeris de Mannheim, 1785, p. 582. Von Hoff, Geschichte der Veränderungen, t. II, s. 541, merely refers to it

[15] *Loc. cit.* p. 590.

[16] *Loc. cit.* 1787, p. 350.

1791. The region around East Haddam on the Connecticut River, a few miles below Middletown, has been the scene of a series of local disturbances which have been noticed since the country was settled, and are referred to by Indian tradition and their name of the place, *Morehemoodus*, or place of noises.[1] The first shock of which the time is recorded was on *May* 16, 1791, at eight o'clock in the morning, when it began by two very heavy shocks in quick succession. The first was more violent. Stone walls were shaken down, chimneys were untopped, latched doors thrown open, and a fissure in the ground several rods long supposed to be then opened as it was discovered soon after. Thirty lighter shocks succeeded in a short time, and more than a hundred were counted during the night. At Killingworth, twenty miles distant, "a Captain Benedict who was walking the deck of his vessel, then lying in the harbor of that place, observed the fish to leap out of water in every direction as far as his eye could reach." The atmosphere was clear, and the very bright moon almost full. On the night of the seventeenth, six more shocks were felt. The weather continued clear and warm.[2]

May 18, 1791, about ten o'clock, P.M., a shock was felt from Boston to New York. A few minutes after came another lesser shock, perceptible at a distance of seventy miles from East Haddam.[3] There the tremor of the earth and the noise in the atmosphere were great. Chimneys and stone fences were thrown down. During the night there was a succession of local shocks to the number of twenty or thirty. Stones of several tons weight were removed from their places, clefts opened in the soil and in the rocks. In Middle Haddam the shock was quite severe, and the direction seemed to be nearly from west to east. It is probable that the earthquake felt at Philadelphia and New York at the same hour, was identical, and not on the sixteenth as reported.[4]

In *December*, an earthquake was felt at St. Paul's Bay, on the St. Lawrence, in Canada, about sixty miles northeast of Quebec. Walls were cracked and stones fell from the houses.[5]

1792. *August* 28, 1792, another earthquake was felt at East Haddam. The forenoon was rainy with an easterly wind which changed in the afternoon to southwesterly. Warm and somewhat squally. Shock at ten o'clock in the evening.[6] *October* 24, at one o'clock in the morning three shocks were felt. The weather was very pleasant.

1793. *January* 11, 1793, at eight o'clock in the morning, another shock of the East Haddam series. Weather warm and pleasant. *July* 6, another at six o'clock in the morning. Weather very warm and damp; rain, with thunder, in the afternoon.

1794. *March* 6, 1794, at two o'clock in the afternoon, there were two, and another at eleven in the evening. Atmosphere clear in the morning, but damp and hazy in

[1] In a letter from Roger Williams to John Winthrop, dated at Providence, probably June 1638, after referring to the earthquake of that year, the writer continues: "The younger natiues are ignorant of the like: but the elder informe me that this is the 5th within these 4 score yeare, in the land: the first about 3 score & 10 yeare since: the second some 3 score & 4 yeare since, the third some 54 yeare since, the 4th some 46 since: & they allwayes observed either plague, or pox, or some other epidemicall disease followed; 3, 4, or 5 yeare after the Earthquake (or Nannaumemoauke) as they speake." Massachusetts Historical Collections, (4th ser.) vol. IV, p. 229. Perhaps these traditions referred to earthquakes from this same eastern Connecticut centre.

[2] Silliman's Journal, vol. XXXIX, p. 338.

[3] Trumbull's History of Connecticut, vol. II, p. 92.

[4] Hamburg Corresp. nr. 128; Moniteur, 23 Août 1791, according to Mallet.

[5] Transactions Royal Geological Society (London), 2d vol. V, p. 97, note to Baddeley's Memoir.

[6] Silliman's Journal, *loc. cit.* Mallet confounds this with the next.

the afternoon. It is reported that a shock was felt in Canada in 1796, "a little before March 6," and some rocks at Niagara Falls were dislodged. Keferstein mentions this, but the fact seems doubtful.[1]

Von Hoff mentions a shock felt at Philadelphia, March 17, 1800, and a severe shock is said to have occurred at the same place November 29 of the same year.[2] On *December* 25, a severe shock was felt at Newport, Boston, Concord, and elsewhere.[3] In November, between the evening of the eleventh and morning of the twelfth, a vibratory shock was felt.[4] *March* 1, 1801, an earthquake is reported.[5] August 23, 1802, a severe shock, attended with a noise like the rattling of a carriage on pavement, was felt at Richmond, in Virginia. (Moniteur, 26 Vendémiaire, an 11.) No other authority has been found, and these letters of occasional correspondents are to be received with great caution. 1800. 1801.

August 11, 1805, at seven o'clock in the evening, two slight shocks were felt at the Haddam locality. Wind southwest in the forenoon, and a thunder storm about four, P.M. Another was felt on *December* 30, at six o'clock in the morning. The atmosphere was moist.[6] At Weston, in Connecticut, a remarkable meteor exploded in December, 1807, and some have referred the concussion produced to an earthquake.[7] 1805.

The Haddam earthquakes were described by the Reverend Mr. Hosmer, of that town, in a letter to Reverend Mr. Prince, of Boston, dated August 13, 1729. Portions of his account are here given: —"As to the earthquakes, I have something considerable and awful to tell you. Earthquakes have been here, (and nowhere but in this precinct, as can be discovered; that is, they seem to have their centre, rise and origin among us), as has been observed for more than thirty years. I have been informed that in this place, before the English settlements, there were great numbers of Indian inhabitants, and that it was a place of extraordinary *Indian powwows*; or in short, that it was a place where the Indians drove a prodigious trade at worshipping the devil."

"Now whether there be anything diabolical in these things, I know not; but this I know, that God Almighty is to be seen and trembled at, in what has been often heard among us. Whether it be fire or air distressed in the subterraneous caverns of the earth, cannot be known; for there is no eruption, no explosion perceptible, but by sounds and tremors, which sometimes are very fearful and dreadful. I have myself heard eight or ten sounds successively, and imitating small arms, in the space of five minutes. I have, I suppose, heard several hundreds of them within twenty years; some more, some less terrible. Sometimes we have heard them almost every day, and great numbers of them in the space of a year. Oftentimes I have observed them to be coming down from the north, imitating slow thunder, until the sound came near, or right under, and then there seemed to be a breaking, like the noise of a cannon shot, or severe thunder, which shakes the houses and all that is in them. They have, in a manner, closed since the great earthquake. As I remember, there have been but two known since that time, and those but moderate."[8] Dr. Trumbull, in his history from which the above is quoted, writing about the beginning of the present century, says: "A worthy gentleman, about six years since,

[1] Bibliothèque Britannique, t. II, p. 86.
[2] Hamburg Correspondence, 1801, nr. 15.
[3] Moniteur, 24 Ventose an 9.
[4] Hamb. Correspond. nr. 25, 1802.
[5] Felt's Annals of Salem, II. p. 113.
[6] Silliman's Journal, vol. XXXIX, p. 339.
[7] *Loc. cit.* p. 336.
[8] Trumbull's History of Connecticut, vol. II, p. 92.

gave the following account of them." "The awful noises of which Mr. Hosmer gave an account in his historical minutes, continue to the present time. The effects they produce are various as the intermediate degrees between the roar of a cannon and the noise of a pistol. The concussions of the earth, made at the same time, are as much diversified as the sounds in the air. The shock they give to a dwelling house, is the same as the falling of logs on the floor. The smaller shocks produced no emotions of terror or fear in the minds of the inhabitants. They are spoken of as usual occurrences, and are called 'Moodus noises.' But when they are so violent as to be heard in the adjacent towns, they are called earthquakes. During my residence here, which has been almost thirty-six years, I have invariably observed, after some of the most violent of these shocks, that an account has been published in the newspapers of a small shock of an earthquake at New London and Hartford. Nor do I believe, in all that period, there has been an account published of an earthquake in Connecticut, which was not far more violent here than in any other place." Although these noises still continue, as will be seen by the list, yet they are now infrequent. No explanation of their usually local character has been given, and the Moodus Hill, or Mount Tom, seems never to have been accurately described by any one acquainted with volcanic formations. It will be noticed, however, that the geological structure of this region is much disturbed.

1810. *November* 9, 1810, at 9^h 15′ P.M., at Exeter, New Hampshire, an earthquake was felt which was accompanied by a very unusual noise. The account given by Judge Samuel Tenney[1] is quite clear and distinct. He was sitting by the fireside when he heard a "very heavy and singular noise" directly under his feet; this was immediately followed by a tremendous report in the atmosphere, which did not, however, shake the house. "It was instantly succeeded by the sound usually attending an earthquake," whatever this may be, "continuing with some little variation of intensity for some forty or fifty seconds," and the vibrations which were felt at the same time were steady and not violent. No damage was done, although animals were frightened. The explosion was heard at Conway, seventy or eighty miles north of Exeter. The shock was most violent between Haverhill and Portsmouth, and its course was northwest and southeast. It was felt on the water, and a vessel running into Portsmouth harbor seemed to those on board to strike bottom. Several persons in different towns who were awake, felt a second shock towards morning.

The Moniteur newspaper contains[2] a letter from Boston, dated November 14, which states the time at 9^h 3′ P.M. The shock at Portsmouth lasted one or two minutes; windows were broken. At Kennebunk there were several shocks during twenty seconds. At Portland the vibration was very slight; the air was very calm until a moment before the shock, when a violent wind arose suddenly.

The earthquakes which shook the Valley of the Mississippi from December 16, 1811, to 1813, were slightly felt to the east of the Alleghanies, and not at all in New England; but during the continuance of this series another of the local disturbances was felt at East

1812. Haddam, Connecticut. On *February* 9, 1812, at 9^h A.M., two slight rumblings were felt. The weather was clear. *July* 5, at 8^h A.M., another of the Haddam shocks. Atmosphere filled with mist and rain.

[1] Memoirs American Academy, vol. III, p. 346.

[2] Janvier 18, 1811.

December 28, 1813, at 4^{h} P.M., during wet weather, another rumbling was heard at East Haddam.[1] 1813.

September 9, 1816, a severe shock was felt at Montreal, and on the sixteenth of the same month a second shock of less violence than the former lasted thirty seconds. These were hardly felt in central New England.[2] 1816.

October 5, an earthquake is reported. Walls were thrown down at Woburn, Massachusetts.[3] 1817.

October 11, 1818, strong shocks were felt along the base of the mountains to the north of Quebec. (Qu. Watekish Mts.) The windows and furniture of the houses were shaken.[4] 1818.

About the middle of *November*, 1819, a slight shock was felt at Montreal, which was followed by a tempest in which rain fell of an inky blackness.[5] 1819.

At the end of *February*, 1821, a slight shock was felt at Quebec, but not noticed in New England.[6] In 1823, May 30, the water rose nine feet in Lake Erie; a slight shock.[7] 1821.

July 9, 1824, a severe shock was felt at New Brunswick, accompanied by a noise like the discharge of cannon.[8] 1824.

October 15, 1826, a violent earthquake was felt at Savannah, in Georgia.

August 6, 1827, at 10^{h} P.M., a slight shock was felt in Indiana. And on the twenty-third of the same month a shock was felt at New London, Connecticut, accompanied by a noise like the rolling of a heavy wagon, the noise increasing for three or four seconds and then decreasing for an equal time.[9] 1827.

August 20, 1828, a light shock was felt in some parts of Canada. February 24, 1828, a violent shock is reported at Washington and Baltimore; and on March 9, between 10^{h} and 11^{h} P.M., two severe shocks were felt, lasting in all 30$''$.[10] 1828.

In *January*, 1829, at the beginning of the month a slight shock is reported at Portsmouth, New Hampshire.[11] 1829.

July 14, 1831, walls and chimneys were thrown down at Murray Bay, Canada.[12] The next year a slight shock was felt at Nova Scotia. 1831.

The shocks were repeated at Murray Bay in March and April.[13] 1833.

April 12, 1837, an earthquake occurred at Hartford, Connecticut, slight, but enough to jar all loose articles, and swing a pendant lamp. In one house a bell rang, and some people ran out of their houses, thinking they were about to fall.[14] 1837.

On Sunday, *August* 9, 1840, an earthquake was distinctly felt in many parts of Connecticut. At Hartford the people rushed from the churches. But in New 1840.

[1] Silliman's Journal, vol. XXXIX, p. 339.

[2] Journal des Débats, Janvier 1, 1817.

[3] Felt's Annals of Salem, vol. II, p. 143.

[4] Annales de Chimie et de Physique, t. XII, p. 426. Quarterly Journal of the Royal Institution, vol. VI, p. 370.

[5] *Ibid*, t. XV, p. 422. *Ibid*, vol. IX, p. 205.

[6] *Ibid*, t. XVIII, p. 415. Archives des Découvertes 1829, p. 190, only repeats the same as preceding reference.

[7] Transactions of the Literary and Philosophical Society, New York, vol. II, p. 1, § 25.

[8] *Ibid*, 1824, p. 213. Annales de Chimie et de Physique, t. XXVII, p. 378.

[9] Columbus, Dec. 1827, s. 197.

[10] Monthly Magazine, August, 1828, p. 202. December 11, 1828, a shock was felt in Georgia.

[11] Preussische Staatszeitung 1829, nr. 62. Von Hoff, Chronik, t. II, p. 315, adds that it occurred in the night.

[12] Transactions of the Society of Quebec, vol. II, pp. 83, 89, 1831.

[13] Transactions of the Geological Society (London), vol. V, p. 98, note. Murray Bay is the centre of frequent disturbances.

[14] Silliman's Journal, vol. XXXII, p. 339.

Haven it was not at all felt in the churches, and only slightly by a few people in their own houses. "At North Milford, six miles west of New Haven, it was not perceived. At Milford, still further west, and at Bridgeport, it was felt and heard distinctly. Hence we hear of it to the north and northeast as very distinct, nine to twenty-five miles from New Haven. It was very perceptible in some parts of Massachusetts — not at all in Westfield. In Worcester County it was severe. In Boston there was nothing of it." Some observers thought the noise proceeded from east to west, others from northeast to southwest; and one who was used to earthquakes, thought that at Chester, in Connecticut, near East Haddam, the rumbling continued half a minute, and its course was from northwest to southeast. At Chester, twenty-five miles east of New Haven, the shock was distinctly noticed. The sound was compared to the roll of thunder, the rumbling of a carriage, and the roar of a chimney on fire. The weather was clear, and the sun shining bright. There seems to be no record of the time of day.[1] *September* 10. A violent shock at Hamilton, Canada, from west to east.

November 11, 1840, a severe shock was felt at Philadelphia, accompanied by a great and unusually sudden swell in the Delaware. On the fourteenth of the same month, there was a noise and shock observed in Philadelphia (not New Haven, as Mallet has it), but the members of the American Philosophical Society could not determine whether it was caused by an earthquake or a meteor.[2]

1841. *January* 25, 1841, several shocks were felt in New York in the morning, lasting from fifteen to twenty seconds in all, with a direction from west to east.[3] During this year a shock was reported in Canada, but it is very doubtful. A large mass of rock fell from a cliff, and was probably the origin of the shocks, as in February, 1796, when a fall of part of the ledge at Niagara Falls caused a tremor which was credited to an earthquake.

1842. *November* 9, 1842, an earthquake at Montreal, Three Rivers, and other parts of Canada, when "the waters of the St. Lawrence were violently agitated."[4]

1845. *October* 26, 1845, a slight shock was felt at New York, and in the western part of New England.

1846. *May* 30, 1848, at 1^h 30′ P.M., a shock was distinctly felt at Newburyport, Salem, and adjacent towns. *July* 10, a series of shocks commenced at Deerfield, New Hampshire, which continued on *September* 12, at sunset; *October* 29, at 9^h P.M.; 31, at night; *December* 2. None of these were severe, and as Deerfield is on the line between Newbury and Montreal, it is remarkable that these tremors were not felt at a greater distance. They were repeated the next year.

1847. *January* 8, 1847, about 3^h P.M., a shock at Grafton Harbor, and a remarkable tide on Lake Ontario. *January* 11, at 11^h 30′ P.M., a shock at Albany, N. Y. The Journal of Commerce, of January 20, reports a slight shock at Lincolnville and Camden, Maine. *February* 2, at Deerfield. On the fourteenth at Meredith Village, New Hampshire, on the nineteenth at Belfast, Maine, and on the twenty-first at Deerfield. All these were light, and very local. *April* 1, at 9^h P.M., at Limington, Maine. *June* 9, a tide was noticed at Lake Winnepiseogee, New Hampshire. *July* 9, in the morning a shock was felt at Glens

[1] Silliman's Journal, vol. XXXIX (2), p. 335. Hartford and New Haven Congregational Observer, August 2, 1840.

[2] Silliman's Journal, vol. XL (2), p. 376.

[3] Comptes Rendus, t. XII, p. 449.

[4] British Association Report. Transactions of Sections, 1845, p. 20. Moniteur Dec. 5, 1842.

Falls. *August* 8, about 10^h A.M., an earthquake was reported at Boston, Dedham, Cape Cod and Nantucket, but not to the north.

The beginning of this year, *January* 1 and *February* 1, shocks are reported in Nova Scotia: the first broke the ice on ponds and opened doors, the second occurred at Yarmouth and Sherburne. It is well known that intense cold, as well as intense heat, causes cracking and subterranean rumbling, and it is necessary to guard against mistaking the origin of similar results. These shocks should probably be referred to atmospheric agencies. 1848.

May 23, a shock was felt at Montreal, followed the next day by a torrent of rain.

September 9, about 10^h P.M., a shock was reported in Rhode Island, Connecticut, New York, New Jersey and Pennsylvania. The Moniteur of September 29, states that a slight shock had just been felt in the northern United States, and this is doubtless the one intended.

November 6, at 5^h 15′ A.M., a light shock at Grand Island, in the St. Lawrence.

December 11, at 3^h A.M., a tremor at Montreal.

February 4, 1849, at Newport, Rhode Island. 1849.

February 15, at Springfield, Massachusetts, also in St. Lawrence Co., New York.

October 8, in the afternoon, through Middlesex County, Massachusetts.

July 20, 1850, at Portland, Maine, in the afternoon. 1850.

January 3, 1851, at Waterville, Maine. 1851.

January 30, at 5^h P.M., a light shock at St. Andrews, Canada.

January 10, 1852, a shock was noticed at Bedford, Massachusetts, which seems to have extended westward to the Connecticut River. The time given in the reports from New Bedford, Providence, Warwick, was 6^h 40′ A.M. 1852.

February 11, 5^h 40′ A.M., at St. Martins, Canada, a light shock from the west-northwest. The barometer stood at 29.067; the thermometer at 38.5 F.

April 30, in the afternoon, a shock was felt in the Eastern States, but principally at Washington and Baltimore.

June 30, at Claremont, New Hampshire, and Windsor, Vermont, both on the Connecticut River.

August 1, at Groton, Connecticut.

August 2, about 11^h P.M., at Bathurst, New Brunswick.

August 11, P.M., at Deerfield again.

November 27, 11^h 45′ P.M., an explosion and a dull noise or rumbling was heard at Newburyport, and through the Valley of the Merrimack, at Beverly, Ipswich, Woburn, Topsfield, Groton, Salem, Danvers and Wareham, Massachusetts, and Portsmouth and Exeter, New Hampshire. At the latter place, the shock lasted half a minute, and shook the houses so as to wake people.[1]

March 12, 1853, between two and three o'clock in the morning, a shock was noticed at Lowville, New York, which threw down machinery. Its direction was east to west, or the reverse, as observers did not agree.[2] Felt also in Canada. 1853.

May 24, at Bytown, Canada.

June 3, two or three shocks at Bridgetown, Nova Scotia.

[1] Silliman's Journal (2), vol. xv, p. 140.

[2] Silliman's Journal (2), vol. xvi, p. 294.

July 17, between 5^h and 6^h A.M., two shocks at Portland, Saco, and other places in Maine.

September 7, 11^h 10′ P.M., at New Bedford and Dartmouth, Massachusetts.

1854. *February* 22–23, 1854, midnight a shock and rumbling, from west to east, was felt and heard at Reading, Massachusetts.

October, a shock at Keene, New Hampshire.

December 4, at 10^h P.M., a shock at Huntington, Canada.

December 10, 12^h 30′ P.M., at Newburyport, Massachusetts, and Exeter and Portsmouth, New Hampshire.

1855. *February* 8, 1855, in Nova Scotia, New Brunswick, and New England, a slight shock. On the nineteenth of the same month a shock in Maine.

1856. *May* 1, 1856, a slight shock at Ottawa, Canada.

December 28, a slight shock at Ottawa, reported by Dawson.[1]

1857. In the Upper Province, Canada, in October, slight.

1858. *May* 10, 1858, at Richmond, Canada.

May 17, P.M., light shock at Richmond. At Sherbrook, about 3^h P.M., the ground moved feebly, with a sound like distant thunder, apparently from the northwest. At Melbourne and Compton the animals seemed much alarmed.

June 30, 10^h 45′ P.M., at New Haven, the tremor lasted more than a minute, accompanied by a sound like a carriage on a bridge, but more sonorous and prolonged; from southwest to northeast. The sky was clear and the air perfectly calm. At Derby the shock was severer than at New Haven; the houses were strongly shaken.[2]

October 8, at 3^h 15′ P.M., a shock was felt in western New York, principally at Buffalo, but also in Canada. The northern end of the line of disturbance seems to have been Port Hope, on Lake Ontario, and the southern, near Warren, Pennsylvania.[3] Eastward it did not pass the Adirondacs, but from its extent into the Montreal region is mentioned in this list. On the eighth of this month a marked shock was felt at St. Louis, and also in Illinois.[4]

1859. A slight shock at Metis, in Canada.[5]

1860. *March* 16, 1860, at 9^h 30′ and at 10^h 15′ P.M., Provincetown, Massachusetts, was visited by two shocks. At Dedham the second shock was felt, attended by a noise like a heavy body falling from the top of a house. It was perceived at Holliston.

October 17, 6^h A.M., an earthquake was felt in Canada, and the northern United States. A number of observations were made, and the following list, prepared by Professor J. W. Dawson, of Montreal, gives a tolerably satisfactory view of the region shaken. The places are arranged in longitudinal order from east to west.[6]

Bic, 6^h A.M. Three shocks at intervals of some seconds, noise continued ten minutes.

Green Island, 6^h A.M.

Rivière du Loup, 6^h A.M. A series of shocks lasting nearly five minutes. A schooner off this place experienced a shock resembling that of striking on a sandbank, and the waters of the Gulf of St. Lawrence were unusually agitated.

[1] Canadian Naturalist and Geologist, vol. I.
[2] Silliman's Journal (2), vol. XXVI, p. 298.
[3] *Ibid*, vol. XXVI, p. 177.
[4] *Ibid*, vol. XXV, p. 136.
[5] Canadian Naturalist and Geologist, vol. V, p. 372.
[6] *Ibid*, vol. V, p. 364.

Rivière Ouelle, 6h 15′ A.M. Very violent, damaging walls and throwing down chimneys, especially in low grounds. An account appeared anonymously in a Quebec paper, as follows: —

Rivière Ouelle, 17 *Octobre*, 1860.

"Ce matin trois fortes secousses de tremblement de terre sont venues jeter la frayeur au milieu de nos populations.

"Les bâtisses situées de chaque côté de notre rivière ont souffert généralement. [Dix-huit cheminées ont été renversées.] La croix de notre église et le coq sur qui la montait sont à terre; les murs de notre belle église sont lézardés. Les secousses étaient effrayantes; la première, la plus violente, à commencé à six heures et quart, et a duré quatre minutes et quarante secondes, très violentes durant dix secondes et s'affaiblissant graduellement; la secousse la plus faible à six heures et vingt minutes, a duré trois à quatre secondes, et la troisième a commencé a six heures et demie, et n'a duré que deux à trois secondes; mais, comme la première, c'était un choc saccadé faisant danser les meubles, décrochant les cadres, les horloges, etc.

"Les secousses ont été plus faibles sur les hauteurs, que dans les plaines, de sorte que mes bâtisses se sont trouvées à l'abri des accidents.

"Jamais de mémoire de nos habitants, nous n'avons eu des coups aussi forts. Je suis demeuré devant mon horloge tout le temps pour m'assurer de sá durée. * * * Un bruit sourd et fort nous a d'abord averti et ensuite sont venus les secousses et les craquements."

Eboulements, near Murray Bay, 5h 36′ A.M. Violent. Five other feeble shocks in rapid succession, another at noon, and another at 5h P.M. This is the only place where these latter shocks are mentioned, but the hour of the first is probably an error.

Bay St. Paul, 5h 50′ A.M. Violent shock; chimneys fell.

St. Thomas (Montmagny), 6h A.M. Two shocks.

St. Joseph de la Beance; 6h 10′ A.M.

Quebec, 5h 50′ A.M. Several shocks, not so severe as at Rivière Ouelle, but especially marked in the low grounds.

Leeds, Megantic, 6h 10′ to 6h 15′ A.M.

Richmond, 5h 45′ A.M.

Three Rivers, about 6h A.M. Shocks felt for two minutes.

Granby, about 6h A.M.

St. Hyacinthe, 5h 45′ A.M. Three shocks continuing more than a minute; buildings reported damaged.

Maskinonge, 6h A.M. Shocks felt for more than a minute. Supposed to be from north to south.

Montreal, 5h 50′ A.M. Two or three perceptible shocks, felt less on the mountain than on lower ground.

St. Martin, Isle Jesus, 5h 55′. At Dr. Smallwood's observatory, two distinct and smart shocks. The wave passed from east to west. Barometer 29.964 inches, temperature 40.3, wind N. E., cloudy.

Cornwall, 6h A.M.

Prescott, 5h 30′.

Belleville, 5h 30′. One shock. This place is about 9° of longitude west of Bic.

Hamilton, 4h 45′ A.M.

In all, or nearly all, of these places the usual rumbling noise preceded the shock, and gradually decreased as it passed. The shock was felt on the Atlantic coast. At Saco, Maine, there was a strong shock. This earthquake was felt as far west as Auburn, in New York, and south to Newark, New Jersey.[1] In Maine, New Hampshire, Vermont and Massachusetts, four light shocks were felt from east to west, with a feeble, subterranean noise.

In *March*, there were two shocks in Massachusetts, according to some reports.[2] 1861.
July 12, about 9 P.M., a shock was felt at Montreal, Ottawa, Prescott, Ogdensburg, Brockville, Saint Andrews and St. Johns, but it was most violent at Ottawa, where it over-

[1] Silliman's Journal (2), vol. xxx, p. 150.

[2] New York Weekly Herald, March 9. Bunker Hill Aurora.

turned chimneys. According to Professor Dawson, it was, in several places, preceded by a dull noise, then a series of light vibrations, which were terminated by a sudden shock. At Prescott, three shocks were reported.[1] At 9^h 3′ a strong shock was felt at Isle Jesus, lasting twenty seconds, and apparently coming from the north-north-west.[2] This earthquake was also felt at Syracuse, New York, where it lasted four seconds, shaking furniture. The date of this shock has been much confused; Perrey places the New York shock on the tenth, and another report gives the eleventh for the disturbance at Isle Jesus. They were all doubtless to be referred to one.

August 31, at 5^h 22′ A.M., two shocks were felt at Washington, at an interval of about five seconds, and each lasted six or seven seconds. The direction seemed to be south to north, and they were felt at Cincinnati, Ohio.

1862. *February* 2, 1862, about 8^h P.M., a strong shock at Colchester, Connecticut; service in the churches was interrupted; at Lyme it lasted three or four seconds. This is in the region of which East Haddam is the centre.

February 4, about 7^h 30′ A.M., at Saybrook, and other towns in Middlesex County, Massachusetts, a shock less than that two days before lasted some seconds.

1864. April 20, 1864, between 1^h and 2^h P.M, a shock more violent than that of 1860 was felt at Quebec but not noticed at Montreal. Two shocks were felt at Danville and Father Point. The time at Quebec was probably 1^h 10′ – 1^h 15′ P.M., and two distinct shocks of five or six seconds duration, were noticed. In the Harvey Hill Mines, at a depth of 180 feet, it was perceptible. At Father Point, another shock at 11^h P.M. is reported.[3]

October 21, 4^h 10′ A.M., four distinct shocks were felt at Montreal. They seemed to come from the east, and each lasted about ten seconds.

1867. *December* 18, 1867, 3^h A.M., a shock is reported in New York and Vermont, as far south as Whitehall, on the boundary of these States; and in British America, from Belleville, Canada, to Sackville, New Brunswick. It lasted about twenty-five seconds. At Burlington, Vermont, most of the inhabitants were waked up. At Syracuse, at 3^h 10′, and the duration estimated at 1′ 30″; direction from south to north, stronger at the commencement than the end. At Ogdensburg, the noise seemed to last two minutes and the vibrations one minute; direction west to east; intensity varying gradually, highest at either extreme. At Hammond, the first shock is said to have occurred at 2^h 50′ A.M., and was followed by others lighter. At 4^h 27′ a final shock. At Montreal, at 3^h A.M. The shock extended from Port Hope on the west, to Trois Rivières on the east.[4]

[As nearly two years have elapsed since this paper was prepared, it has been thought best to continue the enumeration of earthquakes in New England up to the time of publication.]

1869. *October* 22, about 6^h A.M., an earthquake was felt over New England, and the eastern Province. In Nova Scotia it was noticed at Halifax, Kentville and Annapolis. At St. John, New Brunswick, the shock was severe, lasting about 20″, and preceded by a rumbling noise. People were frightened from their houses. At Frederickton, chimneys were thrown down and walls cracked. At New Haven, very few noticed it, and it was even less at Boston.[5]

[1] Canadian Naturalist and Geologist, vol. VI, p. 329.
[2] *Ibid*, vol. VII, p. 43.
[3] *Ibid*, New Series, vol. I, p. 156.
[4] Silliman's Journal (2), vol. XLV, p. 135.
[5] Silliman's Journal (2), vol. XLVIII, p. 418.

1870. *October* 20, 1870, at 11^h 25′ a distinct vibration was felt from New Brunswick to Iowa. The duration and direction of the shock have been variously stated, and illustrate the difficulty of seismic observations, without instruments. By my own observations, the duration was more than a minute. I was seated at a very solid desk, and when the shock commenced was writing, which became impossible, and on looking at my watch, I found that the vibration continued sensibly 43″, but died away so gradually that I could not distinguish it from possible jar from passing teams. No noise could be observed. All persons familiar with earthquakes, know the peculiar feeling of direction, almost indescribable, and very various; sometimes like a train of cars passing under a bridge, but so distinct that the noise or vibration comes from a certain direction. In the present case, the shock, although slight, was sufficient to move a door of my desk that happened to be open, its plane in a south-south-east direction, through an arc of 4°-6° repeatedly and rapidly, indicating a course of, approximately, north-north-east to south-south-west. An observer in the same neighborhood thought the oscillation was from south-south-west to north-north-east, and the duration about 28″.

Many persons in Boston felt a slight nausea, while others did not feel the shock at all. It was felt less on the new-made lands than in the ancient part of the city. In Canada the effects were more severe and walls are reported cracked, and chimneys overthrown. A telegraph operator in Quebec was in the act of enquiring about the earthquake at Montreal, when it was felt at the latter place.

At Portland, Maine, glass was broken; the shock was felt more perceptibly on the wharves. The telegraph operator at Bangor reported the shock about 2″ before it was felt at Portland. About three hundred feet of the Ogdensburg Railroad, sixteen miles from the city, settled ten feet at the time of the earthquake.

At Bath the vibrations seemed east and west, and their duration 15″.

At Bowdoin College, Brunswick, a chimney was broken; the direction seemed north-east and south-west, and the duration 30″–40″.

Augusta, two shocks were noticed; the duration was 25″.

Lewiston, bricks were thrown from several chimneys, and the shock lasted about 30″.

Burlington, Vermont, a distinct shock at 11^h 26′ A.M. There were regular vibrations from south to north, lasting in all about 15″.

Newburyport, Massachusetts, a slight jar was felt, which was immediately followed by a heavy rumbling lasting 30″, jarring buildings and ringing doorbells. It seemed to pass off in a south-westerly direction.

At Cambridge, Massachusetts, Professor Winlock, of the Observatory, considered the direction of the vibrations about 10° north of east, but he judged only from the appearance of the sides of a vessel containing milk.

At Boston, an observer gives the time of the cessation of the shock at 11^h 25′ 37″ Cambridge mean time.

At Springfield, three distinct shocks were noticed, of which the last was the severest, lasting 7″–8″.

At New Haven, Connecticut, and other places, there were two distinct series of vibrations. The shock commenced at 11^h 19′ 15″ New Haven mean time, or 1′ 45″ after it reached Boston, apparently. It lasted ten seconds, and the individual half vibration, lasted about two-thirds of a second; after an interval of five seconds there was another

shock, like the first, of eleven seconds duration. It was thought that the direction was north-north-east to south-south-west. Another report gives the direction as from north-east to south-west, and the duration 20″. Hartford, the shock lasted from 20″–60″, and the wave apparently moved from north-west to south-east.

At Albany, New York, Professor Hough, of the Dudley Observatory, gives the time at 11^{h} 15′, and the duration 1′. A rumbling noise was heard, and a clock pendulum swinging north and south was made to vibrate east and west. Since 9^{h} A.M. of the previous day, the barometer had fallen rapidly .7 of an inch. During the shock the mercury in the registering barometer was violently agitated.

At Cleveland, Ohio, several clocks were stopped, each indicating nearly 11^{h} 45′ A.M. Slight shocks were felt at Richmond, Virginia, and at Dubuque, Iowa.[1]

There were no seismometers in any observatory in New England, and we are again compelled to infer roughly the direction and force.

It was intended when this enumeration of the New England earthquakes was prepared, to supplement it by a full discussion of the geological features of the regions where these have been most frequent and severe, and also by a map of such of the so-called trap regions of New England and the adjacent parts of Canada, as present distinct indications of volcanic origin. Our State Reports have very frequently been prepared by those who, with an admirable knowledge of general geology, have been deficient in the familiarity with volcanic remains, which only a careful study of both the active and extinct systems of volcanoes can furnish. It is probable that the very general, and much abused term "trap" has been given to indurated and obscure aqueous deposits; certainly, not enough care has been exercised in distinguishing the various kinds which occur in our well-known dikes and veins.

Although nearly a century ago attention was called to the phenomena observed at West River Mountain, on the Connecticut River, in New Hampshire,[2] yet no vulcanologist (if this term may be used), has ever examined the mountain, although, if the reports then published were correct, masses of slag, rapilli and scoria were abundant, at or near the crater-like summit. Montreal has been called an ancient trachytic cone. Gay Head, on Martha's Vineyard, and the Moodus Hill, in Connecticut, have had their volcanic nature affirmed, and denied. And the whole valley of the Connecticut River, seamed with dikes and dotted with eruptive cones, is unstudied as yet. No doubt exists that volcanic agencies have been at work here, in comparatively recent times, for the hardened marble of the Vermont beds on either side of dikes, show the hot rock was an intruder on the limestone deposits. The dikes in the conglomerate, near Boston, show the same subsequent date for some of these formations.

When Mr. Percival attempted to report on the geology of Connecticut, he was much impressed with the remarkable and frequent trap ridges and dikes in the centre of the

[1] Silliman's Journal (2), vol. L, p. 434.

[2] Memoirs American Academy, vol. I (1), p. 312. In Dr. Dwight's Travels, is the following: — "At Hinsdale, on the Connecticut River, in the State of New Hampshire, was an eruption of fire in 1752, from a volcanic mountain, called West River Mountain. This miniature eruption was accompanied by a loud noise, resembling the sound of a cannon. A hole was found about six inches in diameter; a pine tree which stood near it, was partially covered by a black mineral substance, forced out of the passage, consisting chiefly of melted and calcined iron ore, and strongly resembling the scoria of a blacksmith forge."

State. He had never seen a volcano, but the curiously radiating ridges, and semi-circular mounds and depressions, suggested a common origin, and that volcanic.

Our geologists are now prosecuting their examinations into the physical geology of New England, in a way unknown when most of the State reports were published; and, although the purpose with which this paper was commenced has been necessarily abandoned for the present, yet these most interesting localities may be examined by those now in the field, and useful results expected.

The regions indicated by the earthquakes catalogued, are as follows: —

1. A region in Canada, somewhat elliptical in form, with the city of Montreal at its western focus.

2. A region around the mouth of the Merrimack River, in New Hampshire and Massachusetts, and extending to Boston.

3. A region smaller than either of the others, around New Haven, Lyme and East Haddam.

These are, as will be seen, comparatively independent, although a severe shock may be simultaneous in all. The trap indications (and the word trap is here used in its popular signification, to mean any felspathic, igneous rocks, containing much augite and hornblende,) are more continuous, and are also widely diffused. Northern Vermont, the Connecticut valley, central Connecticut, and eastern Massachusetts, are in some sort distinct, although not differing so much as to be referred to different ages; for it seems probable that the dikes have been formed at intervals in the same locality, and their formation may be, and doubtless is, now going on from time to time, at various depths below the surface, and by the high temperature they bring in contact with the cold rock, through which they break, or into whose cavities they run, produce the tremors and disturbances we call earthquakes.

TABULAR VIEW OF NEW ENGLAND EARTHQUAKES.

DATE.			EXTENT.		COURSE.
1568					
1574			Eastern Connecticut and Rhode Island. These four are Indian traditions, reported by Roger Williams. See p. 14.		
1584					
1592					
1638	June 1	2h–4h P.M.	All New England: quite severe.		NW–SE
1642	March 5	7h A.M.			
	June 1	1h P.M.	Massachusetts.		E–W
1653	Oct. 29				
1658	April (4?)		New England; violent.		
1660	Jan. 31				
1662	Jan. 26	6h P.M.	New England.	* • •	
	Nov. 6				
1663	Jan. 26	5h 30′ P.M.	Canada and New England.		
	Jan. 28	9h A.M.			
1665	Feb. 24		Canada; slight in New England.		
	Oct. 15	9h 30′			
1668					
1669					
1670					
1706					
1720	Jan. 8				
1727	Feb. 29	10h 40′ P.M.	Centring near the mouth of the Merrimack.	* • • •	NW–SE
	Nov. 7	11h P.M.	Newbury; all slight and attended with noise.		

1727	Nov. 12	3h 30′ P.M.	Newbury; all slight and attended with noise.	
	Nov. 12	4h 30′ P.M.	"	
	Nov. 13		"	
	Jan. 3	9h P.M.	"	
	Jan. 6	9h P.M.	"	
	Jan. 24	9h 30′ P.M.	"	
	Jan. 28	6h 30′ A.M.	"	
	Jan. 28	10h A.M.	"	
	Jan. 29	1h A.M.	"	
	Jan. 30	2h P.M.	"	
	Feb. 21	12h 30′ A.M.	"	
	Feb. 29		"	
	March 17	3h A.M.	"	
	March 19	1h 40′ P.M.	"	
	March 19	9h P.M.	"	
1728	April 28	5h P.M.	"	
	May 12	9h 40′ P.M.	"	
	May 17	8h P.M.	"	
	May 22	10h A.M.	"	
	June 6	3h A.M.	"	
	June 8	3h A.M.	"	
	June 11	9h A.M.	"	
	July 3	2h A.M.	"	
	July 23		"	
	Jan. 30	2h P.M.	A distinct shock at Boston.	• •
	March 19	2h 30′ P.M.	Newbury.	
1729	Sept. 8	3h 30′ (?)	"	
	Sept. 29	4h 30′ P.M.	"	
	Oct. 29	10h 40′ P.M.	"	
	Nov. 14	8h A.M.	"	• •
	Nov. 27	8h P.M.	"	
	Feb. 8	8h P.M.	"	
	Feb. 8	12h M.	"	
	Feb. 26	1h 45′ A.M.	"	• •
1730	April 12	8h P.M.	"	
	July 28	9h A.M.	"	
	Aug. 15	8h A.M.	"	• •
	Nov. 6		"	
	Nov. 14	9h A.M.	"	
	Nov. 25	8h 20′ P.M.	"	
	Dec. 6	10h 45′ P.M.	"	
	Dec. 11	6h 45′ P.M.	"	
	Dec. 12	10h 30′ P.M.	" No noise, but felt at Boston.	——
	Jan. 7	7h P.M.	"	
	Jan. 7	M.	"	
	March 7	5h P.M.	"	
1731	May 28	9h A.M.	"	
	July 5	— A.M.	"	
	Aug. 21	9h P.M.	"	
	Oct. 1	11h P.M.	"	
	Feb. 7	7h P.M.	"	
1732	Sept. 5	11h A.M.	" No noise, but felt at Boston and Montreal.	——
	Dec. 30	— A.M.	"	
	March 1		"	
1733	Oct. 19	M.	"	
	Jan. 16	10h 20′ P.M.	"	
1734	June 29	3h 15′ P.M.	"	
	Oct. 9	10h 20 A.M.	"	
	Nov. 11-12	M.	"	
	Nov. 16	6h A.M.	"	
	Feb. 2	5h 45 P.M.	"	
	March 21	10h 30 A.M.	"	
1736	July 13	9h 45 A.M.	"	
	Oct. 1	1h 30 A.M	"	• •
	Nov. 12	2h A.M.	"	
	Nov. 12	6h A.M.	"	
	Feb. 6	4h 15 P.M.	" Shocks felt at Boston at 4h 30′ P.M.	
1737	Sept. 9	10h 20	"	
	Dec. 7	11h P.M.	" Felt at New York and Boston.	* * *
1739	Aug. 2	2h 30 A.M.	"	
1740	Dec. 11	6h 35 A.M.	"	
	Jan. 18	4h A.M.	"	
	Jan. 25	3h 50 P.M.	"	
N. S.				
1741	Dec. 6	8h A.M.	Boston and vicinity.	——

1741	June 13	10h 35′ A.M.			
1744	May 16		Quebec.		
	June 3		Cambridge.		
	Dec. 23	M.	Newbury.		
1746	Feb. 2	9h–10h P.M.	Boston.		
1755	Nov. 18	4h 11′35″ A.M.	All New England.	* * * *	NW–SE
	Nov. 18	5h 29′			
	Nov. 22	8h 27′ P.M.	Boston.		
	Dec. 19	10h P.M.	"		
1756	Jan. 2		"		
	Nov. 16	4h A.M.	"		
	Dec. 4	10h P.M.	"		
1757	July 8	2h 15′ P.M.	"		
1758	April 24	9h 30′ P.M.	Pennsylvania and Maryland; slight in New England.		
1759	Feb. 2		Boston.		
1760	Feb. 3		New England.		
	Nov. 9		Boston; more severe in the neighborhood.		
1761	Feb. –		"		
	March 12	2h 15′ A.M.	New England.		
	March 16				
	Nov. 1	8h P.M.	Massachusetts and New Hampshire.	——	NW–SE
1766	Feb. 2		Massachusetts and Rhode Island.	——	
	June 14		Essex County, Mass.		
	Aug. 25		Newport, R. I.		
	Dec. 17	6h 48′	Portsmouth, N. H.		
1783	Nov. 29	10h 50′ P.M.	New England and as far as Pennsylvania.		N–S
1785	Jan. 2	7h 15′ A.M.	Cambridge; and about the same time at Baltimore.		
1786	Nov. 29	4h P.M.	"		
1787	Feb. 25	1h A.M.	"		
1791	May 16	8h A.M.	East Haddam, Conn.	* *	
	May 17	– P.M.	"		
	May 18	10h P.M.	" Also from Boston to Philadelphia.		W–E
	December		Canada.		
1792	Aug. 28	10h P.M.	East Haddam.		
	Oct. 24	1h A.M.	"	• • •	
1793	Jan. 11	8h A.M.	"		
	July 6	6h A.M.	"		
1794	March 6	2h P.M.	"	• •	
	March 6	11h P.M.	"		
1800	Dec. 25		Newport, Boston, Concord and elsewhere.		
	Nov. 11-12		Boston.		
1801	March 1		Salem.		
1805	Aug. 11	7h P.M.	East Haddam.	• •	
	Dec. 30	6h A.M.	"		
1810	Nov. 9	9h 15′ P.M.	Exeter, N. H., and northward.		NW–SE
1812	Feb. 9	9h A.M.	East Haddam.	• •	
	July 5	8h A.M.	"		
1813	Dec. 28	4h P.M.	"		
1816	Sept. 9		Montreal; hardly noticed in central New England.		
	Sept. 16				
1817	Oct. 5		Woburn, Mass.		
1818	Oct. 11		Quebec.		
1819	November		Montreal.		
1821	February		Quebec.		
1824	July 9		New Brunswick.		
1827	Aug. 23		New London, Conn.		
1828	Aug. 20		Canada.		
1829	January		Portsmouth, N. H.		
1831	July 14		Murray Bay, Canada.		
1833	March		"		
	April		"		
1837	April 12		Hartford, Conn.		
1840	Aug. 9		New Haven and northward.		NW–SE
	Sept. 10		Hamilton, Canada.		W–E
1841	Jan. 25	– A.M.	New York State.		W–E
1842	Nov. 9		Montreal.		
1845	Oct. 26		New York and western New England		
1846	May 30	1h 30′ P.M.	Newburyport and Salem.		
	July 10		Deerfield, N. H.		
	Sept. 12	Sunset.	"		
	Oct. 29	9h P.M.	"		
	Oct. 31	– P.M.	"		
	Dec. 2		"		
1847	Jan. 8	3h P.M.			
	Jan. 11	11h 30′ P.M.	Albany, N. Y.		

1847	Feb. 2		Deerfield, N. H.		
	Feb. 14		Meredith Village, N. H.	-	
	Feb. 19		Belfast, Me.		
	Feb. 21		Deerfield, N. H.		
	April 1	9h P.M.	Limington, Me.		
	June 9		Lake Winnepiseogee, N. H.		
	July 9		Glens Falls.		
	Aug. 8	10h A.M.	Boston and towards Cape Cod.		
1848	Jan. 1		Nova Scotia.		
	Feb. 1		"		
	May 23		Montreal.		
	Sept. 9	10h P.M.	Southern New England, to Pennsylvania.		
	Nov. 6	6h 15′ A.M.	Grand Island, Canada.		
	Dec. 11	3h A.M.	Montreal.		
1849	Feb. 4		Newport, R. I.		
	Feb. 15		Springfield, Mass., and eastern New York.		
	Oct. 8	– P.M.	Middlesex County, Mass.		
1850	July 20	– P.M.	Portland, Me.		
1851	Jan. 3		Waterville, Me.		
	Jan. 30	5h P.M.	Canada.		
1852	Jan. 10	6h 40′ A.M.	Massachusetts.		
	Feb. 11	5h 40′ A.M.	Canada.	——	{ WNW–
	April 30	– P.M.	New England; more at Washington, D.C.	——	{ ESE
	June 30		Claremont, N. H.		
	Aug. 1		Groton, Conn.		
	Aug. 2	11h P.M.	New Brunswick.		
	Aug. 11	– P.M.	Deerfield, Mass.	——	
	Nov. 27	11h 45′ P.M	Newburyport, Mass.		
1853	March 12	2h–3h A.M.	New York and Canada.		W–E
	May 24		Canada.		
	June 3		Nova Scotia.	• • •	
	July 17	5h–6h A.M.	Portland, Me.	* *	
	Sept. 7	11h 10 P.M.	New Bedford, Mass.		
1854	Feb. 22-23	M.	Reading, Mass.		W–E
	October		Keene, N.H.	——	
	Dec. 4	10h P.M.	Canada.		
	Dec. 10	12h 30′ P.M.	Newburyport, Mass.		
1855	Feb. 8		New England.	——	
	Feb. 19		Maine.	——	
1856	May 1		Canada.	——	
	Dec. 28		"	——	
1857	October		"		
1858	May 10		"		
	May 17	3h P.M.	"		NW–SE
	June 30	10h 45′ P.M.	New Haven, Conn.		
	Oct. 8	3h 15′ P.M.	New York and Canada.		
1859			Canada.		
1860	March 16	9h 30′ P.M.	Provincetown, Mass.		
	March 16	10h 15′ P.M.	"		
	Oct. 17	6h A.M.	Canada and Northern States.		E–W
1861	March		Massachusetts.		{ WNW–
	July 12	9h P.M.	Canada.		{ SSE
1862	Feb. 2	8h P.M.	Connecticut.	——	
	Feb. 4	7h 20′ A.M.	Middlesex Co., Mass.	——	
1864	April 20	1h–2h P.M.	Quebec and Montreal.		
	April 20	11h P.M.	Father Point.	* *	
	Oct. 21	4h 10′ A.M.	Montreal.	• • • •	E–W
1867	Dec. 18	3h A.M.	Vermont and Canada.		{ W–E
					{ S–N
1869	Oct. 22	6h A.M.	New England and Canada.	——	
1870	Oct. 20	11h 25′ A.M.	New England and westward.	——	{ NNE–
					{ SSW

Distributed by months the earthquakes occurred as follows :

In October, 19; November, 29; December, 22; January, 20; February, 36; March, 22. Winter months . .	148
April, 9; May, 13; June, 14; July, 13; August, 15; September, 10. Summer months	74
No month given	9
Total,	231

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II. On the Early Stages of Terebratulina septentrionalis (Couthouy.)

By Edward S. Morse.

Read October 20th, 1869.

THERE is hardly a group among the lower animals (if we consider the relatively small number of species represented by it) that has attracted the attention of so many naturalists as the Brachiopoda. The names of Cuvier, Owen, Vogt, Huxley, Hancock, Gratiolet, Lacaze-Duthiers, Bouchard-Chantereaux, Müller, Davidson, Carpenter, King, d'Orbigny and a host of others, are sufficient evidence of the interest felt in a group whose organization links them so closely with the past.

The desire to interpret through a knowledge of its living forms the many species which are now extinct, as well as to ascertain the relations it bears to the other divisions of the animal kingdom; the contemplation of a group whose maximum development in genera and species was attained in the Devonian age, though its representatives are strewn through the rocks of all ages since the dawn of life upon the globe; the remarkable fact that among the earliest forms of organic life known, are genera whose species can hardly be distinguished from present existing forms, all explain the attractions its study has afforded alike to Zoologists and Palæontologists.

The splendid memoirs upon the Brachiopoda by some of the authors just mentioned, more particularly those of Albany Hancock,[1] Vogt and Gratiolet, offer but little encouragement to one entering the field with the expectation of gleaning anything new. While, however, the anatomy and histology of the adult animal of several species has been carefully worked up, little or nothing has been done toward elucidating the embryology, or the early stages of the class. Fritz Müller[2] has given in a short note a description and two figures of what he considers an early stage of a species of *Discina*, and Lacaze-Duthiers[3] has made some extremely interesting observations on the embryo of *Thecidium*. Aside from these two papers, we know of nothing whatsoever relating either to the embryology or the early stages of the Brachiopoda. The importance and necessity of some information regarding the embryology of these animals has been urged by many writers, for it was believed that the relations between them and the Polyzoa, as urged by Agassiz, Milne Edwards, Huxley, Hancock, Dana and others, would be verified, when the development of Brachiopoda was known. In this path of inquiry the investigator will find an open field.

For a long time I have been interested in the relations of the class under consideration,

[1] On the organization of the Brachiopoda. Philosophical Transactions of the Royal Society, London, 1858, vol. CXLVIII, part 2.

[2] Archiv für Anatomie Reichart et Du Bois Raymond, 1860, p. 72.

[3] Histoire de la Thecidie. Annales des Sciences Nat. 4th series, tome XV, p. 262.

and in an early paper entitled "Hæmal and Neural regions of Brachiopoda,"[1] and later, in a paper on the "Classification of Mollusca, based on the principle of Cephalization,"[2] urged the intimate relations existing between the Brachiopoda and Polyzoa. With the hopes of learning something about the early stages of one of our native species of Brachiopods, I visited Eastport, Maine, in the early part of June, 1869, and this communication embraces a summary of the incomplete observations there made; incomplete, as I was unable to secure any data on the embryology of the species. At the outset my microscope proved altogether inadequate to the work before me, though the minute size of the objects examined, coupled with the complicated texture of the shell through which the soft parts had to be observed, rendered the work, at the best, laborious and difficult. In every case, however, the figures given in the accompanying plates are correct transcripts of the drawings made from the animal: in no instance is there given any combination of several unfinished sketches to make a more intelligible, or perfect whole. This will explain the absence of detail and completeness in many of the figures presented: at the same time it is believed that the outlines will be more valuable from the fact that they are not schematic or composite.

For a clear exposition of the organization of the Brachiopoda, I would refer to the exhaustive memoir of Albany Hancock above referred to, a memoir which justly merited the honor conferred upon him in the award of the Royal medal.

On the early stages of Terebratulina septentrionalis Couthouy.[3] The specimens upon which the following examinations were made, were dredged in fifteen fathoms of water in the harbor of Eastport, Maine, in the first week of June, 1869. The species occur in great numbers, at various depths, and have also been collected at low tide mark, by Dr. Stimpson and Prof. Verrill. The specimens were found attached to stones brought up in the dredge, and also adhering to the lower valve of adult individuals, generally near the peduncle. An examination of adult individuals showed that while the ovaries in some specimens were empty, in others they were fully charged; in some the ovaries would be partially empty, in others the ovaries of one side would be nearly empty, while those of the other side would be quite full. Specimens collected by Prof. Verrill in August, were found with eggs; and eggs were also noticed in specimens less than three sixteenths of an inch in length. The eggs, fig. 1, were generally kidney-shaped, though very irregular as to form and size; they were spermaceti white in color, and opaque, though having a central area, translucent, and apparently depressed. In general outline they suggest the kidney-shaped eggs of *Fredericella*. No intermediate stage was observed between the ovarian egg and the stage represented in fig. 2. This form recalled the general proportions of *Argiope* and *Megerlia*, in being transversely oval, in having the hinge margin wide and straight, and in the presence of a proportionately wide foramen. This stage was exceedingly minute, and only two individuals were discovered; they were attached to the rock, resting on the broad hinge area; nothing could be traced of the structure, except an appearance of granular contents, as indicated in the figure; the shell showed nothing of

[1] Proceedings Boston Society Natural History, vol. IX. 1862.

[2] Proceedings Essex Institute, Salem, vol. IX, part 6 1865. Also reprinted in American Journal Science and Arts, vol. XLII, no. 124. 1866.

[3] A brief resumé of this paper was published in the American Naturalist, Sept. no., vol. III, 1869. Since reprinted in American Journal of Science and Arts for Jan., 1870.

The general results were communicated at the 18th Annual Meeting of the American Association for the Advancement of Science, Aug., 1869.

the scale-like structure so characteristic in later stages. Between this stage and the next, fig. 3, the shell rapidly elongates, while the hinge margin remains nearly the same in width; this is also shown in the concentric lines of growth seen faintly on the surface, indicating a rapid increase in the length of the shell, while no corresponding increase takes place in the widening of the hinge margin. The peduncle is longer than the shell, having distinct walls apparently enclosing a clear interspace, the end slightly dilating and forming a pear-shaped adhering disk. The structure of the shell, of which more will be said in subsequent pages, showed clearly the scale-like structure, with the cæcal tubules of the pallial lobes perforating it. The anterior margin of the pallial lobes gave rise to seven setæ of variable lengths, all of them projecting forward. These setæ, in nearly all instances, were clothed with desmids, and were probably available in attracting sustenance to the animal; they resembled in structure the setæ of the adult, as figured by Hancock, and the longest of them was as long as the shell. The future position of the calcareous loop was indicated by a strongly arched process midway the length of the shell, from which sprang six short and stout cirri, all of them curving towards the mouth, which occupied the centre of the base from which the cirri sprang. The digestive sac hung from the mouth, and was twice as long as broad, having a strong constriction in the centre, forming two chambers, the lowermost one being globular in shape, and having its walls colored a light reddish-brown, this colored portion evidently indicating hepatic cells. The cavity next the mouth indicates the stomach, while the lowermost cavity indicates the future intestine, or cul de sac. The cirri moved frequently, and in various directions, though generally performing a grasping motion, as if securing some bit of food, imitating precisely the movement of the cirri in Polyzoa, and this resemblance was more complete from the fact that the tentacles were densely clothed with cilia (fig. 4), and their movements caused visible currents in the water. The two cavities of the digestive sac were also ciliated, and little pellets of food were seen rapidly circulating back and forth from one cavity to the other. The cavities were alternately dilating and contracting, and assumed the forms represented in figs. 5, 6 and 7. At this stage the lower cavity of the digestive sac was diverted to the larger valve, as represented in fig. 4.

In this stage, and several succeeding stages, the outline of the shell is remarkably like that of *Lingula*, and this resemblance is more striking from the proportionately long peduncle.

In another stage, numerous irregular shaped calcareous spiculæ lined the outer margin of the cirri, while the future position of the calcareous loop, or crura, was indicated by a row of irregular shaped spiculæ, the correct forms of which are given in fig. 15.

Fig. 16 represents portions of two cirri more highly magnified, in which correct outlines are given of the spiculæ. It is to the presence of these calcareous particles that we must account for a certain rigidity noticed in the texture of the cirri. In these slightly advanced stages, the peduncle becomes much shorter in proportion to the length of the shell, though the shell presents the same lingula-like form, differing, however, from *Lingula* in the much greater length of the neural valve, which is always perforated and rostrated from the outset.

In all these stages the peduncle has very slight adhesion to the rock, or whatever substance it may be attached to, in this respect differing greatly from the adult, which often requires great force to detach it, frequently leaving the peduncle separated from the body, and adhering to the rock.

In figs. 8 and 9 are given side views of the shell at this period. The flatness of the valves will be observed, again resembling *Lingula* in this respect; the under valve is much flatter than the upper one. I was fortunate in observing an individual at this age in motion. The animal whirled quickly on its peduncle; when at rest the shells were always closed, and rested on the rock; from this position it turned slowly more than half way round, raising the body at the same time almost erect; this movement being completed, the valves would very slowly open, and the cirri expand as if to perform a grasping motion; in no case, however, were they projected beyond the margin of the valves. The cilia lining the cirri produced gentle currents in the water. In this position, with the valves widely open and cirri expanded, the animal would remain motionless for twenty or thirty seconds, and then, with an abrupt closing of the valves, suddenly assume its first position. These two positions are represented in fig. 10, where the animal is seen from the side, and in fig. 11, where it is seen from above. The outline marked A represents the shells closed and at rest, while B represents the shells open; the line of arrows indicates the direction of the rotatory movement.

In watching these motions for a long time, one could not help being impressed with the fact that caution was evidently indicated in the slow and careful movements made in elevating and opening the shell, while the prompt closing of the valves, and the alert manner in which the animal regained its first position seemed to show that food had been secured, and further caution was unnecessary.

In another stage, fig. 12, the tentacles were seen of various lengths, some of them just budding from the lophophore. A fold upon each side of the stomach was first noticed; these folds are the first appearance of the liver. At this time the hepatic folds expand and contract independently of each other (fig. 14).

In fig. 13 another view of the same individual is given, where the upper portion of the digestive sac, or that portion which answers to the œsophagus and stomach, is in a contracted state, while the lower portion is widely expanded. A peculiar constriction appears at times between the two chambers of the digestive sac, which recalls the cardiac or œsophageal valve, as seen in the Phylactolæmatous Polyzoa; it has no coniform projection into the stomach, and really appears more distinctly as an annular dilatation. All traces of it disappeared during certain expansions and contractions of the gastric walls. All portions of the sac and the lateral folds were strongly ciliated, and the food, now gathered into round pellets, and again scattered in granules, was violently impelled back and forth.

In fig. 4, the cirri are shown, clothed with cilia; in fig. 12 the cirri are shown plain, while the cilia are shown lining the digestive sac. In fig. 15 only the calcareous spiculæ are shown; but in all these cases each possesses the characters of the others, which for clearness are shown singly.

Fig. 17 exhibits the only example where the soft parts are drawn from an alcoholic specimen. In this example is first seen a set of muscles, rendered visible by their contraction in alcohol, and consequent greater density. They are probably the divaricator muscles, though somewhat in advance of what their position would be in the adult state.

Owing to the contraction of the digestive sac, its diverticular cavities are sharply defined, and the globular appearance of the lower cavity is marked. In another alcoholic specimen of the same age, a band, evidently one of the lateral gastro-parietal bands, was

made out. As this could not be verified in other specimens of the same age, the figure is not given.

A still more advanced stage is shown in fig. 21. The shell is now becoming proportionately broader, and the cirri increase in number, though still forming a simple circle around the mouth. The crura have also begun to form.

In fig. 22 a considerably more advanced state is shown. The valves have been forcibly separated, and the smaller one is thrown back. The cirri are more numerous, numbering thirty-one; two of them are seen encroaching upon the circular lophophore, and at this stage the lophophore has begun to assume its hippocrepian character.

The crura (*cr*) are plainly seen supporting the crown of cirri, and the liver already shows the first indications of its differentiations into the peculiar cæcal ramifications which become so numerous in the adult; and at this stage is seen the division of each lateral portion of the liver into a dorsal and ventral lobe; a lateral lobe is shown in fig. 23. It will be seen that the liver is divided into a series of cæca, though these are united.

The divaricators (*d*) are completely formed, and between these two muscles is seen the lengthened intestine (*i*), the blind extremity of which is held firmly to the shell by a membrane, called by Hancock the ventral mesentery.

The appearance of the shell at this stage is represented in fig. 26. Radiating ribs, to the number of fifteen, ornament the shell. It will be seen by this figure, that the setæ correspond in growth and position to the radiating furrows, and this observation is also made by Hancock in his examination of the adult. A well defined concentric line seems to indicate the earlier lingula-shaped shell, and though no ribs appear in the earlier stages, they are defined upon this area afterward, and it would appear from this that the ribs are formed on the inner surface, and that the setæ direct and induce the furrow. The lobes of the liver (*l*), and the peduncle (*p*) and peduncular capsule, are shown in this figure.

In fig. 24 a stage still more advanced is given; the valves are thrown back, disclosing the stomach and intestine suspended from the calcareous loop. The crura (*cr*) are well defined, and the ventral mesentery (*vm*) is more distinctly seen in this figure. Two lateral bands are seen holding the stomach in position; and these appear to be attached to the crura, though they probably pass by them, and become attached to the hæmal valve. These are the lateral gastro-parietal bands first described by Huxley.

The walls of the blind intestine are yet light brownish in color, as in the Phylactolæmata, and, as before remarked, are hepatic. A kidney-shaped area is faintly defined on the neural valve. A portion of this outline indicates the point of attachment of the perivisceral wall.

In fig. 24*a* an enlarged view of the digestive sac and adjacent parts of fig. 24 is shown. The liver in this stage communicates with the stomach by large openings on each side, and fine granules were seen rapidly circulating to and fro, from the liver to the stomach. The fæces, rolled into a spiral and pyriform shape, were constantly in motion by the action of the cilia lining the stomach. This mass was frequently urged toward the mouth before it was finally discharged. The passage of the fæces through the mouth was repeatedly witnessed; though after the careful investigations of Huxley, Hancock, Lacaze-Duthiers and Gratiolet, no further proof is needed of the absence of an anal outlet to the intestine of this, and allied species.

The experiments of Mr. Hancock, such as bursting the intestines under a compressor,

were performed on many living adult specimens, yet in no case was the slightest evidence of an anal outlet observed.

Fig. 25 represents a stage but slightly advanced from fig. 24. The cirri are more numerous, but still spring from a circular lophophore.

Fig. 27, plate II, represents a considerably advanced stage, in which the lophophore, before circular, has rapidly assumed its hippocrepian character; rapidly, — since forms nearly of the same size show no marked indications of change, for in one example we may have a circular lophophore, or one showing but slight indentation, while in another example, hardly differing in size, we have the lateral processes well advanced in development. It is possible that we may have here a feature observed by Fritz Müller in the young *Discina* described by him; he mentions the remarkable fact of having repeatedly captured free swimming young which had evidently advanced further in their development than the oldest of those which had already fixed themselves. It will be noticed that in this stage (fig. 27) the cirri stand erect upon the arms, that is pointing towards the anterior margin of the shell, and that the arms are not deflected. This stage of the lophophore vividly recalls the hippocrepian forms among the Polyzoa, such as *Plumatella*, *Cristatella*, *Lophopus* and others.

The liver now shows its adult characters in having its ramified cæca separated, and not adhering by their walls in one mass. In this early condition it resembles the liver of Thecidium, as described and figured by Lacaze-Duthiers.

Fig. 28 represents a stage where the arms become deflected; as yet no central process of the lophophore is developed; the mouth is very large, and that margin of it not bearing cirri is very pliant in its movements.

In the next stage (fig. 29) the arms are more deflected and make a sharper curve in their approach together, and the central process of the lophophore is indicated by that portion forming the base of the inner curve, developing into two prominences. The free lip is seen in irregular curves, and these changed with every movement of the parts.

Fig. 30 represents a slightly more advanced stage, where the central processes of the lophophore are more developed. The free lip is here seen thrown broadly back, disclosing a capacious mouth, within which are seen two blunt projections, though in another view of the mouth (fig. 31) only one projection was observed. The free lip seemed to perform all the functions pertaining to the epistome in the higher Polyzoa, and we find it on the inner bend of the arms, as in the Polyzoa, though not occupying the same homological position in regard to the flexture of the intestine. It will be noticed that in all these stages the cirri are comparatively thick.

In the stage represented by fig. 32, the cirri become more attenuated and increase rapidly in number; the central process is more advanced, though not yet thrown into a vertical spiral, as in the adult, and the mouth has lost the broad reflected character of the lip, which it possessed in the earlier stages, though the free lip has yet considerable pliancy, as seen in figs. 33 and 34, where other views of the same mouth are presented. For the first time now appears another adult character, in the apparent decrease in the length of those cirri in the median line of the mouth.

In figs. 35, 36 and 37, different aspects of the mouth of an adult individual are shown; figs. 35 and 36 representing the outline of the mouth alone, while in fig. 37 the cirri are shown. In these three views the oral tubercle (*ot*), as it may be called, is strongly

marked. The same projection is represented in the mouth of *Thecidium Mediterraneum*, as figured by Lacaze-Duthiers. A singular lunate groove, running parallel with the free lip, is indicated in the figures, which may be called the oral groove (*og*). It seems more like a wrinkle caused by the expansion of the free lip, though its limits are well defined and the furrow is quite deep.

The independent movements of the cirri are shown in fig. 37; these are just as pliant in their movements as in those of the extreme young, and at all times recall the motions of the cirri in the Polyzoa.

Structure of the Shell. In the younger stages of the shell the peculiar scale-like structure may be studied to the best advantage. The scales are few in number, but slightly overlapping, and form a layer quite distinct from the outer layer, which appears to be homogeneous, save the concentric lines of growth appearing like rows of oblong and flattened nodules. The terminal portions of the pallial cæca within or upon this outer layer, are brown in color and distinctly granulated. I failed to make out anything satisfactory regarding the character of these peculiar parts. In a few doubtful cases I thought I saw one or two tubules radiating from the terminal ends of the cæca, and in fig. 38, A, one observation is represented. It will be seen by this that the tubules radiate from the largest diameter of the cæca, and not from the periphery of the granulated disk, and this is in accordance with the admirable observations made by King.[1] The scales do not appear to encroach upon the walls of the cæca.

Fig. 38 shows a small fragment of the shell at an early stage; portions of five scales are here seen forming the inner layer of the shell. In the earlier stages, when they are large and few in number, the scales are flat; now and then showing a raised line caused by the encroachment of two superincumbent scales, between which the under scale is closely adjusted. This may be seen in fig. 39, and better in fig. 40, where the ends of the scales are broken, and show in section; also in fig. 41, where, in a later stage, they become more numerous; here the terminal ends of five scales are shown in juxtaposition.

In fig. 42 a portion of the anterior margin of one valve is shown. The newly formed scales are just indicated near the border, beyond which the outer layer projects.

Fig. 43 represents two scales from a stage still more advanced; here the numerous lines upon the scales indicate their closer aggregation. As the shell increases in age, the scales become more attenuated, and now the scale is diverted wherever it encounters a cæcal process, and forms a yoke or loop around it.

In fig. 15, plate I, a few spiculæ at the base of the cirri mark the commencement of the calcareous loop. At a later stage the spiculæ increase rapidly in number, and finally anastomose, appearing as in fig. 44. The scales composing the base of the crura are acicular in shape, and run parallel with the crural axis. In adult specimens the scales of the crural supports resemble acicular crystals, and when boiled in a solution of caustic potash, glisten and separate, resembling the fibres of asbestos (fig. 47).

Fig. 46 represents the crural process of one side, taken from a specimen less than an eighth of an inch in length. It exhibits the first stages of the loop. The acicular scales are shown at the base, while the remaining portion is made up of scales similar to those

[1] Prof. W. King, on the Histology of the Test of the Class Palliobranchiata. Transactions of the Royal Irish Academy, vol. XXIV, pt. xi, 1869.

composing the shell. From an extremely young specimen I observed these same peculiar acicular scales (fig. 45), and they probably indicate the presence of the crura.

Nothing of a satisfactory nature was made out regarding the structure of the shell in the earliest stage (fig. 2, plate I), though had the shell possessed the peculiar scale-like structure and cæcal perforations, they would have been visible.

Growth of the Shell. Figs. 18, 19 and 20, plate I, severally show portions of the hæmal valve, neural valve, and the valves connected, from an early lingula-form stage. In fig. 18, the hinge plate (*hp*) and the dental socket (*ds*) are well marked; in the earlier stages of their development the crura appear as slight projections. In fig. 19 the prominence of the so-called teeth of the shell (*te*) is given.

Fig. 20 represents the valves joined; the cæca are seen perforating the entire margin of the shell about the foramen, which is very wide and rudimentary.

On plate II a series of stages are given to show the gradual development of the crura, and parts surrounding the foramen. The upper line of figures in this series, marked N, represents the neural or ventral valve, and the lower line of figures, marked H, represents the hæmal or dorsal valve. In the youngest of these stages, figs. 48 and 49, a broad gap in the neural valve indicates the peduncular foramen. It will be seen that the shell is folded upon each side of the peduncular passage. These folds never meet in this species.

Figs. 50 and 51 show a slightly more advanced stage, the difference being mainly in the greater prominence of the crura.

In the next stage, figs. 52 and 53, the calcareous loop is well advanced, though not yet connected by a continuous shelly layer, though at all stages these portions are connected by a membrane charged with spiculæ. Figs. 54 and 55 represent similar portions of an adult shell for comparison. It will be seen that the neural process of the loop becomes connected, while the hæmal process does not become so connected, though in some specimens it closely approximates. The peduncular opening becomes more circular, and the cardinal process (*cp*), which does not appear in the earlier stages, is now present.

Figs. 56, 57 and 58 are added, to exhibit the relative outlines of the more prominent stages in the growth of the shell. Compare, also, fig. 2, plate I, where the shell is as long as it is broad, and the hinge margin represents the greatest transverse diameter of the animal. In fig. 56 the shell elongates, with the sides nearly parallel, and the peduncular opening wide and gaping. (The line accompanying the figures represents the natural size of the shell.) Fig. 57 represents a stage intermediate between the lingula form and the adult; the peduncular opening is more contracted, the sides of the shell are no longer parallel, though the hinge margin has nearly the same outline as in the first stage. Fig. 58 represents the adult shell. Here the outline assumes entirely different proportions, being nearly oval, while the hinge margin forms a sharp angle, and the foramen is quite circular.

Relations with the Polyzoa. The general affinities of the Brachiopoda with the Polyzoa, as indicated by Milne Edwards, Huxley, Hancock, Agassiz, Hyatt and others, are admitted by most zoologists.

In the preceding examinations of the early stages of *Terebratulina*, we have additional evidence of their relationship. In the evolution of the lophophore, from its circular character, surmounted by a few cirri, to that of the hippocrepian stage, we have suggested, first, the circular lophophore in the inferior, or Gymnolæmatous Polyzoa, and finally, the

bilateral lophophore of the superior, or Phylactolæmatous Polyzoa. The brachial fold, a delicate membrane bordering the lophophore, immediately within which the cirri spring, as seen in *Lingula* and *Discina*, may properly be compared to the calyx in the higher Polyzoa. Still later the presence of a distinct fold bordering the mouth, very pliant and active, may be compared as to function and position, with the epistome of the Polyzoa, though not occupying an homological position in regard to flexure of intestine. It would appear that the membranes suspending the stomach and intestine in the perivisceral cavity, have some relation to the funiculus in the Polyzoa. In *Paludicella* there are two flexible cords connecting the stomach and the endocyst, called by Allman the anterior and posterior funiculus, to which are attached respectively the ovary and testis. In *Lingula* and *Discina* we find the reproductive organs attached to bands, that connect the stomach and intestine to the perivisceral wall. In *Alcyonella* the ovary arises from the endocyst, and likewise in *Terebratulina* and allied genera we find the mantle, or endocyst, holding the reproductive organs.

The early appearance of the divaricator muscles in *Terebratulina* would justify Mr. Hyatt in his views, that these muscles represent the retractors of the Polyzoa.[1]

The combination of the stomach and intestine in their early stages, with the presence of hepatic cells lining their inner walls, and the presence also of a cardiac valve or constriction, all recall similar parts in the higher Polyzoa.

That these relations may be carried farther, there is no reason to doubt. Fritz Müller has noted in an early stage of some species of *Discina* (though from observations I have made in *Lingula pyramidata*, the embryoes examined by him are as likely to belong to this genus, as to *Discina*) several sets of setæ, which project from the body and are capable of locomotion. F. A. Smitt[2] has noticed in the development of *Lepralia Peachii*, a cluster of six bristles bent at their points, that from time to time were drawn in and again thrust out.

With propriety may also be suggested a certain parallelism between the leading groups of the Polyzoa and the Brachiopods. We have forms, like *Lepralia*, attached by one region of their shell, this shell being calcareous and exhibiting minute punctures, which have been compared to similar markings in certain Brachiopods. So among the latter group do we find forms attached, as in *Thecidium*, and some species of *Productus*; and generally the articulate Brachiopods might be compared to such forms as *Lepralia*, while on the other hand such genera as *Pedicellina*, with its long, pliant and muscular stalk, or *Loxosoma*, with a stalk highly retractile, may be compared to *Lingula*. The limits or intentions of this paper will not allow any considerations regarding the relations of the Brachiopods with the other groups of the animal kingdom. I have elsewhere[3] expressed my belief that they are true articulates, having nearer affinities with the Vermes; and in view of the above relations of the Brachiopods with the Polyzoa, it is interesting to remark

[1] A. Hyatt. Observations on Polyzoa, suborder Phylactolæmata. Proceedings Essex Institute, vols. IV, V. Salem, Mass.

[2] Om Hafs-Bryozoernas utveckling och fettkroppar. Öfversigt af Kongl. Vetenskaps-Akademiens Forhandlingar. Stockholm, 1865.

[3] The Brachiopoda, a revision of Annelida, American Journal Science, July, 1870. Reprinted in Annals and Magazine of Natural History, London, no. 33, vol. VI, 4th series.

that Leuckart has for a long time placed the Polyzoa with the Vermes, and in a new edition of the "Outlines of Comparative Anatomy,"[1] Prof. Carl Gegenbaur removes the Polyzoa from the Mollusca, and associates them with the Vermes.

Explanation of Plates.

PLATE I.

Fig. 1. A few eggs in their natural position, from pallial membrane of an adult individual.

Fig. 2. Earliest stage noticed. This was attached to rock, resting upon broad hinge margin.

Fig. 3. Another stage in which the body has rapidly lengthened, and the peduncle is equal in length to the remaining portion of the animal.

Fig. 4. Stage in which a few cirri are developed with the œsophagus and stomach hanging below.

Figs. 5, 6, 7. Œsophagus and stomach of last individual, showing different conditions of expansion and contraction of the parts.

Figs. 8, 9. Partial lateral views of the shell of fig. 3.

Fig. 10. Represents the animal at rest, and in action.

Fig. 11. The same from above; the arrows indicating the direction of rotation.

Fig. 12. A state more advanced, with the liver as a simple hepatic fold on each side of the stomach.

Figs. 13, 14. Different states of contraction of incipient hepatic folds of fig. 12; and showing cardiac contraction in fig. 14, *c*.

Fig. 15. Crown of cirri to show calcareous spiculæ. [For distinctness and to simplify the drawings, the cilia clothing the cirri are only shown in fig. 4, the simple outline of cirri in fig. 12 and the calcareous spiculæ in fig. 15. It will be understood, however, that each figure possesses all the characters of the others.]

Fig. 16. Portions of two cirri highly magnified to show more plainly the form of spiculæ.

Fig. 17. Alcoholic specimen in which divaricator muscles were visible owing to contraction of the parts in alcohol. This is the only figure drawn from a preserved specimen. All the others are from life.

Fig. 18. A portion of hæmal valve.

Fig. 19. A portion of neural valve.

Fig. 20. The same portions before separation.

Fig. 21. A slightly more advanced stage, showing crown of cirri.

Fig. 22. A still more advanced stage, with hæmal valve forcibly thrown open, showing divaricator muscles with stomach between. The crown of cirri shows first indications of its bilobed character.

Fig. 23. An hepatic mass from one side; at this stage showing the first forming of cæcal folds.

Fig. 24. A stage more advanced; valves forcibly separated in which all the parts are plainly seen.

Fig. 24, A. A highly magnified view of the stomach, hepatic folds, lateral bands, etc., of fig. 24. This figure shows a fæcal mass rolled in a spiral form, in the act of being discharged through the mouth. The line bordering the upper portion of the figure indicates the inferior margin of the crural process.

Fig. 25. The hæmal valve with crown of cirri, etc.

Fig. 26. A view of fig. 22 with the valves closed.

PLATE II.

Fig. 27. A stage considerably more advanced than preceding ones, showing lophophore already bilobed, the cirri, however, not deflected. The cæcal lobules of liver few in number but separated. In fig. 23, plate I, the lobules are just indicated.

Fig. 28. Showing lophophore, with cirri deflected. The stomach and blind intestine hanging below.

Fig. 29. The arms of the lophophore more sharply bent; the central processes first indicated. The highly flexible lip is here seen in folds.

[1] Grundzüge der Vergleichenden Anatomie. Zweite ungearbeitete Auflage. Leipzig, 1870.

Fig. 30. A stage slightly more advanced than the preceding. The lip is seen thrown back, disclosing the capacious mouth.

Fig. 31. Another view of the same opening.

Fig. 32. A stage more advanced, in which the lophophore begins to assume the characters of the adult. The cirri are now more numerous and more attenuated, and the lip is not so widely reflected.

Figs. 33, 34. Showing the mouth of fig. 32 in different states of contraction.

Figs. 35, 36, 37. Views of the mouth of an adult individual, showing oral tubercle, and oral groove.

Fig. 38. Fragment of shell highly magnified, showing scales, tubules and outer layer, with lines of accretion indicated by rows of flattened, bead-like nodules.

Fig. 38, A. Exterior portion of tubule, showing radiating pores.

Fig. 39. Single scale.

Fig. 40. Single scale, broken across, and showing ridge in section.

Fig. 41. Five scales in position.

Fig. 42. Fragment of anterior portion of hæmal valve.

Fig. 43. Two scales from an adult specimen.

Fig. 44. Portion of crural process from early stage.

Fig. 45. Acicular scales from early stage.

Fig. 46. Right crural process, from early stage.

Fig. 47. Acicular scales from base of crural process of adult.

Figs. 48, 49, 50, 51, 52, 53. Portions of hæmal and neural valves of early stages showing development of crura.

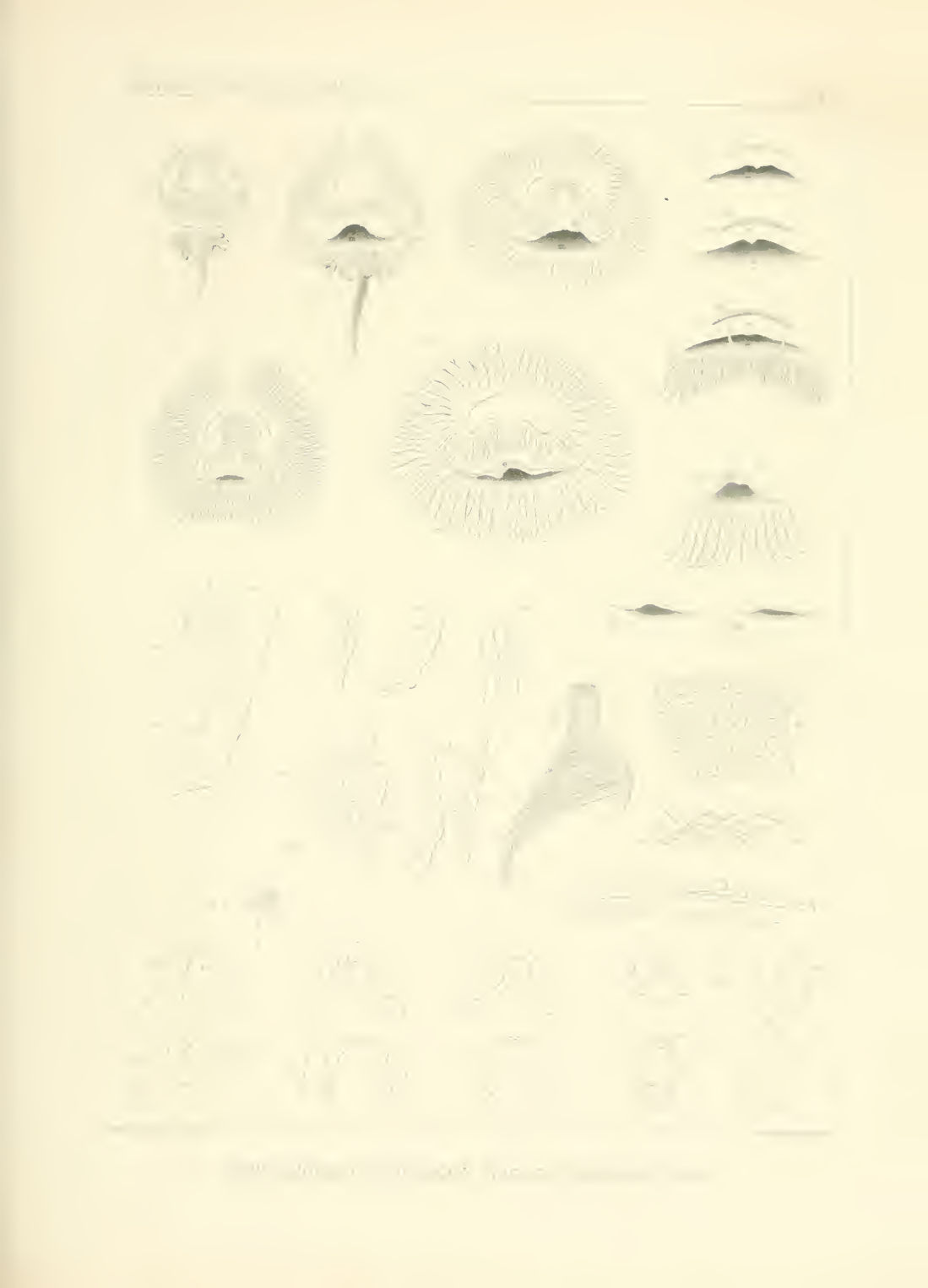
Figs. 54, 55. Corresponding parts of adult, natural size.

Figs. 56, 57, 58. Outlines representing different stages from extreme young to adult, fig. 58 being natural size.

NOTE.—No means of measurement were at hand when the original studies were made. A line enclosed by a circle indicates the entire length of the shell from which the parts were drawn. Where the size is not indicated, it will be understood that the parts are from equally young stages, unless otherwise described in the explanation of plates.

EXPLANATION OF LETTERS ACCOMPANYING THE FIGURES.

m, mouth.
e, epistome.
œ, œsophagus.
s, stomach.
c, cardia.
i, intestine.
f, fæces.
vm, ventral mesentery.
l, liver.
h, hepatic cells.
og, oral groove.
ot, oral tubercle.
d, divaricator muscles.
lb, lateral gastro-parietal bands.
p, peduncle.
pa, point of attachment of peduncle.
se, setæ.
cm, pallial cæcum.
t, cirri.
g, granules passing to and fro from liver to intestine.
cr, crura.
cl, calcareous loop.
ex, external shell layer, of a chitinous nature.
in, internal shell layer, of calcareous scales.
cœ, pallial cæca.
hp, hinge plate.
cp, cardinal process.
ds, dental sockets.
fo, foramen.
te, teeth of shell.
cs, calcareous spiculæ.
cn, notch for pallial cæca.
H, hæmal valve.
N, neural valve.



III. The Osteology and Myology of Didelphys Virginiana. By Elliott Coues. With an Appendix on the Brain. By Jeffries Wyman.

Read October 6th, 1869.

INTRODUCTORY.

Some account of the general traits of *Didelphys Virginiana*, its external form and covering, and dentition, may properly precede, and serve as an introduction to, the study of its bones and muscles. Among other articles upon its anatomy, physiology, and zoology, those cited below may be consulted.[1]

The present memoir is based upon original dissections and preparations, from which all the descriptions have been taken, except in a few instances where the contrary is stated; and all the illustrations were drawn by the writer from the same sources.

The opossum's form is adapted to the execution of numerous and varied movements, but not fitted for great strength, sustained effort, or rapid progression. The animal is sluggish, usually moving slowly and deliberately; its fastest pace is a kind of amble, when both legs of the same side are simultaneously moved, as is also the case when it is walking more slowly; it has not been observed to trot or lope. It is plantigrade, and the body is usually carried so low as to barely clear the ground. The body is thickset and clumsily shaped; the centre of motion is behind the middle, as shown by the general contour, as well as by the trend of the spines of the vertebræ. Extension of the body, as a whole, is less conspicuous than flexion, and is not ordinarily exhibited except when the animal is hanging suspended by the tail; but the body may be bent double, or rolled in a ball, with the greatest ease, the fore and hind feet passing by each other at the middle of the belly, and the nose pointing backward, reaching the root of the tail. The faculty of bringing the fore-paws and snout into such unusual positions is undoubtedly in subservience to the necessity of certain voluntary acts on the part of the female during and immediately after the act of parturition, such as the removal of the helpless fœtus to the pouch, and subsequent fostering of it. Great power of flexion is also essential to ready recovery of an ordinary position after suspension by the tail; as may easily be shown by holding up one of these animals in this position, when it will be observed to bend the neck and shoulders strongly forward, reach upward with its fore-paws until it can catch

[1] Owen. Article Marsupialia: Cyclopedia of Anatomy and Physiology, III. (1841.)

Meigs. American Philosophical Society. April, 1847. (Reproduction.)

Bachman. Proceedings Academy Natural Sciences, Philadelphia, pp. 40, 46. April, 1848. (Reproduction.)

Audubon and Bachman. Viviparous Quadrupeds of North America, II, 107, pl. 66. 1851. (Description and Natural History.)

Baird. Mammals of North America, 232. 1857. (Description, etc. See other authors there quoted, for Zoology, etc.)

Owen. Anatomy and Physiology of Vertebrates, II, and III, *passim*. (1866-68.)

hold of the loosely hanging hind feet; further action of all four extremities carries the paws to the root of the tail, which is firmly grasped, when the animal climbs up its tail "hand over hand" until the point of support is laid hold of; after which, by a peculiar squirming motion of the whole body, the desired attitude is attained. The same power of flexion is brought largely into play in most scansorial movements. Lateral motion of the body is also unusually free. The neck is short and thick; its motion is chiefly that of flexion. The head is of moderate size, appearing in life scarcely separated from the body, regularly cone-shaped, with little, if any, constriction at base, tapering gradually to a slender, elongated muzzle. The nostrils open at the sides of the extremity of the truncated, hog-like snout; the animal is reputed to have excellent olfactory powers, and the supposition is borne out by the large nasal chambers and sense capsules. The eyes, placed far up on the sides of the head, are small, with rather poorly developed lids; presumably in relation to eminently nocturnal habits. The external ears are extremely large, rounded, thin and membraneous, mostly naked, suggesting those of certain cheiroptera; the sense of hearing must be judged acute, if characters of the pinna afford a criterion. The rictus is long and ample; the lips thin and scanty; the large and numerous teeth are a conspicuous feature; the upper canines protrude beyond the lip, and lie outside the lower lip when the mouth is closed.

The opossum is pedimanous; as truly four-handed, perhaps, as many, or any of the quadrumana. The well-developed clavicles of the fore-limb, and the free coxo-femoral articulation of the hind one, permit both extremities to be widely separated, each from its fellow, and render easy the "hugging" movements necessary in climbing. Pronation and supination of the forearm are perfect; the wrist joint, besides revolving freely upon the ulna, is capable of great extension and flexion; of abduction and adduction in less degree. The fingers have much the same relative lengths as those of the human hand; but there is less difference between them, the little finger especially being comparatively longer and stouter, and the thumb longer, less divaricating from the axis of the other digits, and less freely opposable. This condition of the thumb results mainly from the more nearly perfect parallelism and closer union of its metacarpal bone; still it is "opposable," in the proper sense, and may easily be brought in contact with the tip of any finger, or of all together. The five anterior digits are unguiculate; the claws are non-retractile, and therefore stout, short, blunt and only moderately curved. The member, as a whole, is to be reckoned among the more perfect hands afforded by animals lower than man. Its ambulatorial function is secondary in importance; it finds its highest and proper use in climbing, in gathering food, and conveying it to the mouth; and in conjugal and maternal offices. The foot is nearly as much of a "hand" as the hand itself; it is equally fitted for grasping. The hallux, compared with the thumb, is even shorter, and more inclined from the axis of the other digits, to which it is freely opposable. It bears no claw; it is club-shaped, with a rounded extremity; in place of the claw there is a well-marked semilunar groove. The other toes are unguiculate; the claws are like those of the fingers, but longer, slenderer and more curved; the first three toes are of nearly equal lengths, and united by continuous integument beyond the first joints; the little toe is much shorter, but relatively, if not absolutely, stouter than the rest. The general shape of the foot recalls the quadrumanous type. The movements at the ankle are remarkably free, and seem to be more than simply analogous to those of the wrist. As

to flexion and extension, the plane of the sole may sweep through an arc of more than 180°, moving from beyond a perpendicular to the axis of the leg, to beyond a parallel with the latter. The other movements of the foot, by whatever name they may be designated, amount to this: that the sole may present perpendicularly inward or outward, as well as horizontally downward, by extent of adduction and abduction; and the toes may point either inward, forward, outward, or directly backward, by extreme rotation. The first two sets of motions result from the ankle joint alone, but the whole limb is concerned in rotation.

The prehensile tail supplies a "fifth hand." This member is from two-thirds to three-fourths as long as the head and body together; thick and stout at the base, where there is no very evident point of distinction from the body; regularly and very gradually tapering to an obtuse tip; nearly circular on a cross-section, but somewhat flattened underneath, as if by constant pressure. The vertebral articulations and the muscles are so determined that the tail cannot be bent or curled upward, except near its base, where, also, lateral flexion is most marked; when not in use the tail is habitually carried with the tip curled under, so that it resembles a note of interrogation laid sideways ⟃. It has also a peculiar power of being twisted upon its axis, particularly toward the extremity, and so winding like a cork-screw around slender supports. The prehensile power is so great that the animal can suspend itself with only an inch or so of the tip of the tail hooked over a branch. Notwithstanding the general similarity of the long naked tail to that of a rat, it does not appear to have by its weight any special function of balancing the body when the animal is moving over uneven surfaces, as a rat's tail is supposed to have; its use is strictly limited to prehension; it chiefly comes into play when the animal is climbing, and more particularly assists it in gathering fruit from the extremity of the branches. The young attach themselves to the parent's body by the same means.

Most parts of the body are covered with two kinds of fur. The general covering is a kind of true wool, very fine, short, densely packed, of "kinky" fibre, imbricated and furrowed (scaly-imbricate), and with little or no pigmentary matter. Interspersed through this fur on most parts of the body are numerous true hairs, much longer, straight, stiffish, smooth and cylindrical, uncolored at the base, but loaded with coloring matter on the terminal third or half. These hairs are most numerous above, on the sides, and about the root of the tail; but they are nowhere thick enough to hide the true fur. Below, and on the insides of the limbs the fur alone exists. The hair almost fails on the terminal third of the head; the extremity of the snout is naked. The fur extends for two inches or more on the tail; the hairs project a little further. On the extremities the fur stops at the bases of the fingers and toes, and sides of the soles and palms; but the digits are sparsely hairy. A very fine, soft, short fur clothes the scrotum and lines the marsupium. The whisker-hairs are stout, stiff, straight and very long, but not numerous.

A few colorless, bristle-like hairs sparsely cover the backs of the fingers and toes, which are otherwise naked, as are the palms and soles, where the integument is thickened and variously modified, forming callosities, etc., or changing into horny plates. (Fig. 1, *a*, anconal, and *b*, palmar, aspect of hand: fig. 2, *a*, rotular, and *b*, plantar, surface of foot; nat. size.) Above, the digits are covered with somewhat irregular transverse scutella, scarcely overlapping, each divided once or twice across. The palms and soles are studded with small, round, convex tubercles; and the former have six, and the latter five,

prominent callous pads, arranged and shaped as in the accompanying figures. The fingers and toes have on their under surfaces similar but better developed tubercles, to the tips, which are enlarged and rounded, and, like the pads, are not tuberculate, but present fine, curved ridges and depressions of cuticle, like the tips of the human fingers. These roughened and scabrous surfaces have evidently direct relation to the scansorial nature

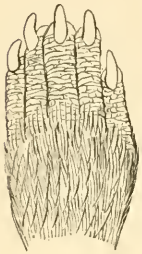


Fig. 1, *a*.

Fig. 1, *b*.

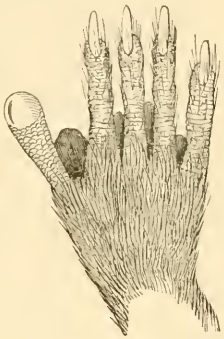


Fig. 2, *a*.

Fig. 2, *b*.

of the animal; and corresponding modifications occur in the integument of the tail, which assumes an almost corneous condition by thickening and hardening of the epiderm. As far as the hair extends, the skin of the tail is simply tough and dense; beyond this, the outer covering becomes harder and divided into small plates. These are oval or subcircular, or somewhat polygonal, from mutual apposition. Pigment granules appear in irregular blotches near the base; the tail is otherwise colorless. A few short, bristly, colorless hairs, like those upon the digits, lying closely appressed, are sparsely scattered over the whole tail. At any given point the scales are largest and flattest above, smallest and most tuberculate underneath; their average size diminishes regularly, with the tapering of the tail; they are regularly disposed in oblique rows, like the dorsal scales of serpents; there are about thirty in a circumference; the obliquity is slight, a row making an advance of about four scales' length in each half turn. The reticulation is somewhat imperfectly represented in fig. 3, which shows the side of the tail, of natural size, at junction of first and second thirds.

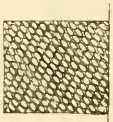


Fig. 3.

Fig. 4.

Short fur ascends a little way on the back of the ear, but disappears below the meatus in front. Most of the ear is flat and "foliaceous"; but toward the base it is much vaulted. The very thin lobule is of moderate size, full and rounded. The posterior margin of the pinna nearly reaches the root of the lobule, and forms a flap on the inner aspect of the latter. A crescent-formed protuberance lies just outside the termination of the anterior margin of the conch, which latter is lost in a transverse fold of integument that forms the anterior or ex-

ternal wall of the meatus, running across to meet a fold of the lobe itself. A triangular fossa is bounded by these two folds and the anterior margin of the ear. (Fig. 4.)

The ear and other naked parts of the body appear to have a low grade of organization, or at least less vitality than ordinary. Under unfavorable conditions, as when the animal is closely confined for a length of time, the ears, tail and digits are susceptible of ulceration, and often rapidly slough away. The Schneiderian membrane is peculiarly subject to hæmorrhage; epistaxis may be brought about, for example, by the passage of a current of electricity, or by very moderate violence.

The ano-genital orifice, as usually observed, has a puffy, inflated, almost prolapsed appearance, as if imperfectly guarded by the sphincter: the penis is almost always, however, withdrawn. The abdominal scrotum is loosely pendulous, almost pedicellate; its livid bluish color appears through the short fur. It is capable, however, of marked contraction; and the testicles may be closely drawn up. The pouch may be detected at a very early age; but in the virgin, though full grown, female, it is never conspicuous, and would escape observation unless sought for; it appears simply as a slight duplication of the skin, capable of admitting the tips of two or three fingers. It rapidly increases with use, and attains a large size, after which, though diminishing somewhat, it never returns to its original condition. The furry lining, at first colored like the rest of the belly, acquires during the pouch-gestation a fulvous or reddish hue; the nipples, at first small, concealed in folds of the skin that are scarcely perceptible, become very prominent, and are surrounded by a naked aureole. There are thirteen nipples, one central, the rest disposed in a circle. The lip of the pouch can be brought very near, if not in actual apposition with, the genital orifice. The transfer of the newly-born young to the pouch has been shown to be accomplished by the voluntary act of the parent, with lips or paws, probably the former.

The reproduction of the opossum, for a long time a subject of wild or fanciful speculation, has been satisfactorily determined by the researches of Dr. Bachman and others: to which, however, it would be out of place to more than allude in the present connection. The full history is given in the papers of this gentleman, already cited. Among the many curious beliefs that still pass current with the vulgar upon this subject, may be mentioned one that ascribes to the opossum, in consequence, doubtless, of the bifurcation of the penis, a coitus with the nostrils of the female; subsequent sneezing, on her part, upon the teats of the pouch causing the young to grow there.

The opossum is extremely tenacious of life. It is, in fact, rather difficult to kill one for dissection without mutilation of some part. In consequence of the shape of the parts, it is not easy to reach and pierce the medulla; a better way is to open the heart with a slender bistoury introduced between the ribs. I found poisoning with cyanide of potassium to be the most convenient method, with the additional advantage of affording a means of studying the operation of that very violent poison; but for rapid effect a larger quantity is required than would be expected to suffice; perhaps fifty times the amount that would almost instantly kill a pigeon. The most noticeable effects are at first profuse salivation, then unsteadiness of gait and general tremulousness, succeeded by clonic spasms alternating with perfect rigidity; ending with complete relaxation, accompanied by copious alvine and urinary evacuations. The time required is from five to fifteen minutes, according to the dose, and strength of the subject.

The natural history of this quadruped has been so fully elucidated by Audubon and Bachman, that little remains to be learned. It is strictly nocturnal, like many, if not most marsupials. The females, indeed, hardly leave their retreats at all during the two months of uterine and pouch gestation. As the teeth show, it is omnivorous; any quadrupeds or birds that it can overpower, eggs, reptiles, insects and worms, berries and fruits of all sorts, form its food; it will at times eat carrion, half a dozen individuals having been found at one time feeding on a dead cow. At certain seasons, especially in the fall, it acquires a deposit of fat, chiefly in the subcutaneous tissue, rivalling in amount that of a well-fed hog, and when in this condition its flesh is palatable. Particularly when thus fortified, it may fast a long time without inconvenience; and under ordinary circumstances can survive for three or four weeks without food or water. An individual upon which I was experimenting passed this length of time with no other food than its own tail, which it gnawed off and ate during the last few days before it was killed. According to Dr. Bachman it sometimes becomes quite tame; but all the individuals I kept in confinement remained to the last as sullen and ferocious as when first caught. It has no voice beyond a low growl, and a sort of hiss when provoked; under the influence of fear or anger a transparent viscid saliva drops constantly from the mouth. Its personal habits, in close confinement, are filthy; the odour, which under the most favorable circumstances is not agreeable, becomes very disgusting after a time. To a common observer it appears dull and uninteresting in confinement, passing the day huddled in a corner, and the hours of darkness in persistent endeavors to escape. It ordinarily, or at least for a long while after capture, refuses food by daylight, and resents too familiar approach by a sinister expression, and the display of a formidable set of teeth. If fortitude under physical pain, and acceptance of death without dismay, be tests of courage, the opossum is one of the bravest of beasts; no amount of torture can draw from it a sign of suffering. Such endurance, joined with remarkable cunning, enables the animal to feign death so perfectly that it frequently escapes, and not seldom retaliates upon its persecutors with an unexpected wound from its sharp teeth. These are well known traits, that have given to the English language a proverbial expression of peculiar significance.

THE TEETH.

Dental Formula: — Inc. $\frac{5-5}{4-4}$; can. $\frac{1-1}{1-1}$; prem. $\frac{3-3}{3-3}$; mol. $\frac{4-4}{4-4}$; $= \frac{26}{24} = 50$.

As the foregoing formula shows, four kinds of teeth are present, and indicate an omnivorous animal of carnivorous propensities. In number the lower teeth only differ from the upper in being one less on each side, by the absence of one pair of incisors. In size and shape, however, the upper and under teeth, especially the molars, differ considerably. The dentition apparently comes nearest to that of *Thylacinus cynocephalus*, among *Didelphia*, and thus resembles that of the *Canidæ*. (For general comparisons of the teeth with those of other marsupials, see Owen, Comp. Anat. and Phys. Vert., III, p. 285 *et seq.*)

Upper Jaw. The median pair of incisors are longer than the rest, and stand a little apart from the succeeding ones. The others are in close juxtaposition, though not usually in actual contact; and of the same size. All are simple, straight, short, somewhat compressed, with slightly enlarged head, not pointed or edged, but obliquely truncated,

resulting in a flattened, cutting surface that looks forward and inward. The long axis of the tooth is almost vertical: the root is unicuspid and rather longer than the exposed portion. An average incisor, root and all, is a fourth of an inch long.

A considerable interval occurs between the incisors and the canine, for the reception of the lower canine. The upper canine is of remarkable size; this formidable weapon is as large, comparatively, as—even if it does not exceed—the tusk of the *Felidæ* or *Canidæ*. The whole tooth is over an inch in length, in an adult male; rather more than half its length protrudes from the socket. In the female, the tusk is both relatively and absolutely smaller. The large root causes a protuberance of the jaw-bone along its course; the base is abruptly truncate, with so large a cavity that the rim of the opening is a thin, sharp edge. The canine is compressed laterally and curves regularly from base to tip in the arc of a large circle; so, although the course of the root in the alveolus is obliquely forward, the point of the tooth is directed downward, and a little backward. In an unworn condition, the tooth tapers to an extremely sharp point, which reaches below the edge of the mandibular alveolus. The opossum's bite is severe, and inflicted mainly by the four canines, which the animal can easily thrust through stout boot-leather.

The first premolar is much smaller than the other two, from which it is separated by a wide interval. It is inserted immediately behind, in juxtaposition with, the canine, and almost appears like a basal snag of the latter. It has two very long, slender, parallel roots, curving slightly backward; these roots do not join to form the body of the tooth until fairly outside the socket; a slight groove is continued downward from their point of union. The exposed portion of the tooth is very small—scarcely half as long as the root; it tapers rapidly to a single sharp point, with no noticeable basal dilation. The second and third premolars successively enlarge; the exposed portion correspondingly preponderates over the rooted part; the latter is deeply cleft into two prongs as before, but these are stouter, straighter and divaricating a little from each other. These teeth are unicuspid, like the first premolar, but heavier, blunter, with a thicker base; and at the base of the posterior border a well developed snag is given off. The second premolar touches the third by means of this basal snag: the third is opposed to the first molar by the same means.

The first three molars are very similar to each other in essential characters, and increase in size from first to third; the fourth, or wisdom tooth, is smaller than either of the others, and differently shaped. It is cut later than the rest; I find it scarcely protruding from its socket in an animal two-thirds grown. The cutting of all the molars appears from before backward. The molars are in mutual contact by their external borders; the triangular shape of the crown produces a large interval between contiguous teeth along the inner border. The crown of the first three molars has the shape of a right-angled triangle, with nearly equal base and perpendicular. The anterior border proceeds straight inward toward the median line of the mouth; thence with a rounded termination obliquely backward and outward to meet the external border. Each of the three corners of the teeth developes a moderate cusp: the middle of each side rises into a smaller tubercle (that of the oblique side being the largest); the grinding surface surrounded by these elevations is irregularly concave. On viewing the molars from the outside, each appears almost divided into two by a deep notch in the lower border, which is opposite a similar notch in the upper border, formed by the late confluence of the fangs.

The molars have three roots, corresponding to the three corners of the crown; two of the roots are side by side, and external; the third stands alone; all are straight, slender and nearly parallel; each prong enters the alveolus by a distinct perforation of the bone. The last molar has three roots like the others, but these are differently disposed. The outer one stands alone, and is much larger than the other two, which are placed side by side, though they still enter the alveolus by separate apertures. The surface of the tooth, instead of being triangular, represents half an ellipse divided along its major axis; the curved border is posterior; the straight one is nearly transverse, like the corresponding anterior border of the preceding molars. The crown of this tooth presents an elevated rim and a central depression, divided into two halves by a raised line that traverses the short diameter. The inner and outer angles of the two parts have slightly developed cusps; the middle of the straight border rises in a small point. The surface represented by the conjoined crowns of all the molars is but little convex in the longitudinal direction; the point of greatest convexity is at the penultimate molar, whence the curve sweeps rapidly up past the last molar, and more gradually up along the anterior ones. The most prominent molar just reaches a line drawn from the tip of the canine to the apex of the paroccipital. The grinding surface of the last molar looks directly downward; that of the others is more and more obliquely bevelled from third to first, so that the grinding surface of the conjoined molars is twisted upon itself. The transverse diameter of the upper molars contrasts strongly with the narrowness of those of the lower jaw. (For upper teeth, see fig. 10 and fig. 11, p. 64.)

Lower Jaw. The four incisors on each side repeat the main characteristics of those of the upper jaw, but the median pair are not noticeably longer than the rest, nor do they stand apart from the others. These teeth are in close proximity to each other, but not touching. The chief peculiarity is their great forward and outward inclination; the anterior ones, in fact, are almost horizontal, instead of vertical. When the jaw is closed, the four teeth are opposed to the interspaces between the four lateral upper incisors, falling inside the line, and not reaching the median pair of the latter.

The lower canine is smaller than the upper, but still of great size. It is inserted in juxtaposition with the last incisor, and closes in front of, and inside of the upper canine, in the wide space that occurs between the latter and the upper incisors. Its root is longer than the exposed portion, much flattened, and inserted very obliquely in the bone. The free portion is stout at the base, rapidly tapering to a sharp point, and much curved, to bring the tooth into the vertical position from its very oblique line of insertion. As a whole, the tooth is notably twisted upon its axis. It measures, in adult examples, nearly an inch in length.

The first premolar is situated midway in the wide interval between the canine and the second premolar. This brings it directly under the upper first premolar, and leaves room for the apex of the upper canine to descend between it and the lower canine. This tooth repeats the characters of the corresponding upper one, but is still smaller. The second is much the largest of the under premolars, but scarcely differs otherwise from the third, with which it is in contact by a largely developed basal snag on the posterior border; a similar snag upon the third connects the latter with the first molar. These teeth close in advance of the corresponding upper ones; so that the second premolar passes by its posterior border along the anterior border of the second upper one; the latter is wedged

between the second and third under premolars, its apex resting upon the basal snag of the former; the third under premolar is similarly wedged between the second and third upper ones; the latter, again, fits in the interspace between the third under premolar and first molar, with its apex touching the basal snag of the former. Each of the premolars has two long, stout, straight roots, parallel with each other; they cause a deep sulcus to appear on both inner and outer aspects of the exposed portion of the tooth, before uniting to form the single, compressed, conical cusp. The anterior border is a little convex; the posterior twice concave, as a result of the projection of the basal snag.

The four molars are remarkable for possessing but two roots apiece, like the premolars, instead of three as those of the upper jaw have. In the formation of the crowns, however, the transition from the premolars is abrupt and decided. The roots are straight, slender, terete, tapering, diverging but little from each other, following each other in the line of the axis of the jaw-bone, and are two or three times as long as the exposed portion of the tooth. The contour of the crown corresponds to the absence of a third (inner) root; it is a narrow rectangle, without angular extension inward. While quite as long as the upper ones, each for each, the lower molars have not half the breadth of the latter; when the two sets are apposed in the closed jaw, a considerable part of the grinding surface of the upper molar lies external to the under series. The molars progressively increase in length, width, heighth and prominence of the several irregularities of surface, from first to fourth. The antero-external corner of each presents a concave depression for the reception of the cusp upon the posterior border of the corresponding upper tooth; a larger excavation upon the face of the crown, at its back part, similarly receives the prominent inner corner of an upper molar. Between these two depressions the outer border of each molar rises to form a prominent conical cusp, attaining the greatest elevation on the last of the series. Behind the cusp is a smaller one, at the postero-external angle of the tooth; the postero-internal corner makes a still less prominent cusp. The antero-internal angle rises highest of any; its strong cusp is partially divided in two by a notch. (For under teeth see figs. 7 and 8, page 62.)

The upper molars have much more of the character of true "grinders" than the lower; the latter are evidently better fitted for the laceration of animal tissue than for the crushing of vegetable fibre. The crowns of the upper molars chiefly present obtuse rounded inequalities of surface; those of the lower show conical sharp-pointed projections.

The whole series of lower teeth is twisted upon itself, and traverses the jaw obliquely, as shown in fig. 8.

PART I. — THE BONES.

1. The Skull.

The cranium is to be considered under three different aspects. First, as being a phase of the mammalian modification of what has been called the vertebrate archetype; representing, as such, four vertebræ, the elements of which have been subjected to changes of relative size and shape, and also, in many instances, to dismemberment or displacement, and the essential characters of which have been further modified — not to say obscured — by the addition or intercalation of accessory and appendiculate parts, as well as by the

suppression, or at least the want of distinctness, of certain parts found in those crania that depart less from the primitive type. Secondly, as being composed of numerous individual parts or pieces; that is, of separate bones, suturally joined with contiguous ones, but not continuous through coössification; such parts expressing not only the division of the skull into four vertebral segments, but also the distinction of the several elements of each segment, and of its appendages. Thirdly, as a complex whole, resulting from the coherence or confluence of all these several proximate and ultimate parts; as such forming a bony box to contain and protect the brain and organs of the special senses. From the first view may be learned the ultimate, or true, or *de jure* morphology of the skull; from the second, its proximate or apparent, or *de facto* morphology; from the third, its teleology, which is the aim and end of all morphology. The cranium, *quoad* four vertebræ, represents or typifies the skull of all vertebrates; as to its individual bones, the skull of all mammals; as a whole, only itself — so far is general morphology modifiable for special teleology.

No two leaves of the forest are precisely alike; no opossum's skull is an exact duplicate of another's. One skull may be so described that the description will not apply to any other one; or in such a way that the terms employed will indicate the skull of any vertebrate; and each of the two methods are perfectly truthful. An account of individual peculiarities only would be tediously profitless; a summary of class, ordinal, or family points alone, would leave much to be desired; a description of specific characters is alone satisfactory, for these mark one entity amidst innumerable forms of animal life. Specific description of a skull may be more general or special, according as more or fewer relations are considered. In a general way, the relations of the opossum's skull to the crania of other vertebrates may be indicated in a description of its four vertebræ; to that of other mammals, in a notice of its different bones; and to that of other marsupials, in its consideration as a whole. It suits my purpose to take up these three lines of description, and in the order just indicated.

a. Of the skull as four vertebræ (*diarthromeres*[1]).

V. epencephalica.—The hæmal arch rests upon the thorax; the centrum and neural arch can usually be detached entire from the antecedent vertebra, without disturbing the latter. The only element that ever coössifies with the antecedent segment is the neural spine, and this confluence only takes place in aged skulls. The neural spine is rarely consolidated with the neurapophyses; the latter, though meeting above the foramen magnum to complete the neural canal without the intervention of the neural spine, remain distinct from each other, but early unite with the centrum. The parapophyses even sooner unite with the neurapophyses; coössification is completed in specimens that still show traces of separation between neurapophyses and centrum. In physical characters, the occipital

[1] "*Diarthromere.*— A word needed to supplant 'vertebra,' in the sense attached to this last in this paper. 'Vertebrate' may be sufficiently definitive of a back-boned animal, but 'vertebra,' at best a meaningless name of certain 'bones,' is inadequate to express the required idea of a whole segment of an animal constructed upon the double-ring plan, besides being so firmly contracted by custom that the necessary expansion is undesirable, if not impracticable. The typical segment—zoönule, or somite—of single-ring animals (Articulates) is already called *arthromere*, of which the proposed word is an obvious analogue."—*New York Medical Record*, *Dec., 1870.*

Although we should of course prefer to employ this term, which we recently proposed, as above, yet it is now practically impossible to revise the MS. for this purpose.

segment, as a whole, is not more unlike the succeeding one — the atlas — than the latter is unlike the axis; or than this last is different from a coccygeal, for instance.

Aside from the displacement of its hæmal arch, its chief modifications relate to its firm sutural (instead of loose articular) connection with the antecedent vertebra, and to the expansion of its neural arch to accommodate the epencephalon. Taking away the expanded neural spine, the three remaining elements form an osseous ring very similar in general appearance to the atlas. It does not appear that the sum total of the modifications that this vertebra has undergone in becoming a part of the "skull" instead of the "spine," is greater than that suffered by the contiguous cervical one, which latter is none the less a "vertebra" for wanting centrum, neural spine and hæmal arch; and it is certainly less than that characterizing the last coccygeal,—a bone that has nothing of a vertebra but a degenerate centrum, fails to perform the essential office of a vertebra, and is only recognized as a vertebra in virtue of its location, being to all purposes, as well as appearances, the distal phalanx of a digit. Comparison of the two ends of the chain of vertebral links shows that teleological modification is less obscure in the guise of hypertrophy, than under the mask of atrophy; exaltation of the function of parts may entail less change than degradation; the caudal larval vertebra deviates more from the archetype than the cranial imago does.

V. mesencephalica. Centrum and neurapophyses coalesce with the same elements of the antecedent (frontal) segment; the compound bone so formed ("sphenoid") is simpler than in some mammals, from not including an appendage of the maxillary arch; for the pterygoid is a distinct bone, as in birds. The neural spine is large, coincidently with increase in size of the encephalon, though it is itself surpassed by the frontal spine. It is developed from two centres, and the lateral moieties so long remain discrete, that they are so found in the great majority of adult specimens; but they ultimately fuse together; they never coössify with either frontal, squamosal, or sphenoid; they reach their proper neurapophyses. The parietal parapophyses (mastoid) are disconnected with that arch, coössified with the acoustic capsule, and wedged in between the latter, the occipital neur- and par-apophyses and the distal element of the appendage of the palato-maxillary arch, which appendage serves as a strong osseous bridge connecting the hæmapophysis of the nasal vertebra with the par- neur-apophysis of the ultimate and penultimate cranial segments, and slightly joins, also, the neural spine of the occipital segment. Besides the extensive confluences and sutures that the parietal segment presents, it also contains — *i. e.*, is the site of — the frontal pleurapophysis, — the proximal element of the mandibular arch (tympanic). This, however, has no osseous connection with the rest of the skull; its relation to the parietal segment is merely one of position. The proper pleurapophysis of the parietal segment (stylo-hyal) is wanting; the other elements of the hyoidean arch[1]

[1] The os hyoides may be conveniently noticed in this connection. The size and general shape are shown in the accompanying figure (fig. 5). The five pieces comprising the hyoid are usually (always?) distinct: I have never seen them anchylosed. The thyro-hyals are elongate, much compressed in an oblique plane, enlarged at either extremity, slightly curved in the continuity. The cerato-hyals are small, flat, triangular nodules remaining cartilaginous for a considerable time. They are mostly supported upon the basi-hyal, but also touch the thyro-hyals. The basi-hyal is small; as high as wide; irregularly five-sided, or rather sub-quadrate, with a thickened, upright, posterior, lower border between the ends of the greater cornua, spreading obliquely upward and forward into a thin lamina with slightly thickened sides, supporting the lesser cornua, and having its sharp, free anterior border somewhat produced by cartilage. There is no uro- or glosso-hyal; no lytta could be found in the substance of the tongue. The cerato-hyals do not appear to have ever formed two pieces.

Fig. 5.

are only connected with the skull by soft tissues, and are removed from its immediate vicinity; the styliform occipital parapophyses appear to perform, as far as muscular attachments are concerned, the office of the hyoidean pleurapophyses.

V. prosencephalica. The confluence of the frontal centrum and neurapophyses with those of the parietal segment, has just been noticed; these elements are distinct from their homotypes of the nasal vertebra. The neural spine, at first in lateral halves, speedily consolidates into one piece, but coössifies with none of the numerous surrounding parts. It is remarkable for its size, and for taking greater part in the formation of the olfactory chamber, than in the protection of the prosencephalon. Frontal parapophyses are wanting; at least no post-frontals can be demonstrated, nor is there evidence warranting the assumption that they are included, otherwise than theoretically in the frontal, or a neighboring, bone. It may however, be surmised, that the super-orbital protuberances of the frontal bone may represent, teleologically at least, such parapophyses; since they subserve the usual function of limiting the orbits posteriorly. The pleurapophysis is disconnected with the other elements of this vertebra, dislocated, lying between the last and the penultimate vertebræ, and pressed into the service of the organ of hearing; it is a delicate little half-ring, supporting the membrana tympani and ossicula auditûs. As already noted, it has no osseous union with the rest of the skull; and even its membranous attachments are of the loosest nature. No trace of separation of hæmapophysis from hæmal spine is usually to be observed; nor is there any distinction of the several hæmapophysial elements that remain distinct in lower classes, and may theoretically be taken to exist in the present example. The hæmal spine is permanently separated into halves, as far as osseous symphyseal union is concerned. The frontal hæmapophysis not only articulates with the distal element of the maxillary appendage, as usual in mammalia, but also with the proximal element of the same; and moreover—what is a rare modification — with the parietal neurapophysis, (squamosal, malar and alisphenoid thus conniving to form the glenoid cavity); it is not connected with its own, or other pleurapophysis.

V. rhinencephalica. The centrum, permanently distinct from that of the succeeding vertebra, is an attenuated osseous spiculum, only having solidity behind for articulation with the presphenoid; it is in intimate relation throughout with the enormously developed olfactory sense-capsule. The neurapophysis, if it have any actual existence, is obscure, and not to be satisfactorily demonstrated in any part of the olfactory capsule; but it may be conjectured that the vertical "septum nasi" represents coalesced pre-frontals. The neural spine is permanently bifid, and remains distinct from surrounding bones; like its centrum, it has been subjected to longitudinal extension and attenuation, to close in the upper wall of the conical muzzle. This vertebra has no diapophysis. The pleurapophysis forms but little part of the maxillary arch, though still performing its proper office much more notably than does the same element of the frontal vertebra. As usual, it is curiously distorted in shape, and closely wedged in between numerous elements not of its own, but of two succeeding, vertebræ. The development of the nasal hæmapophysis corresponds with that of the frontal; it articulates not only with its fellow, its pleurapophysis, and its hæmal spine, but also with the neural spines of its own and of the succeeding vertebra; it likewise supports, in part, a mucous scale-bone and convolutions of a sense-capsule; and besides is connected, through the intermedium of two accessory appen-

dicular pieces, with the neur- and par-apophysis and neural spine of the parietal, and neural spine of the occipital, vertebra. So the nasal hæmapophysis connects mediately or immediately, its own with each of the three other cranial vertebræ; such extensive connections not only contribute to the strength and fixity of the palato-maxillary arch itself, but of the whole skull. The hæmal spine is permanently double; it maintains distinctness from the hæmapophysis; above, the apex of the neural spine is wedged in between its lateral moieties; below and anteriorly, these are in mutual apposition, thus closing in the termination of the neural canal. The "diverging appendage" of the palato-maxillary arch (pterygoid), a delicate scale-like bone, loosely attached, extends backward under the centra of the frontal and parietal arches; it falls far short of the frontal pleurapophysis, instead of connecting the latter with the nasal pleurapophysis, as in birds; nor is it subservient in any way to either the stability or the mobility of cranial segments. The orbital dermo-skeletal, and the acoustic and olfactory splancho-skeletal, bones are elsewhere noticed: the opthalmic sense-capsule is unossified.

b. Of the Several Cranial Bones.

Most of the cranial bones of this low mammal retain their individuality; a few others only coössify with age; several are confluent from an early period of their formation, if not originally connate. The skull is readily disarticulated, and reducible to a greater number of pieces than is the case with higher mammals. Nearly all the bones afford instructive evidence of their morphological characters. The comparatively few compound bones result from confluence of but few morphologically distinct elements: there is no such complex "bone" as, *e. g.*, the "sphenoid" or "temporal" of anthropotomy. The mammalian modification of cranial vertebræ may therefore be studied under advantageous circumstances.

The skull ordinarily falls into the following pieces, some of which are simple, and others compound, bones; the latter are in italics:—*occipital*; superoccipital; *two petromastoids*; parietal, either single or double; tympanic (with ossicula auditûs attached); *sphenoid*; *vomer with ethmo-turbinal*; frontal, single or double; two nasals; two premaxillaries; two maxillaries; two palatals; two pterygoids; two malars; two squamosals; two lachrymals; and the *mandible* (qu. italics), in halves. Sometimes the great sagittal crest comes off the parietals, having only sutural union, and being apparently developed in the fascia between the temporales. The superoccipital may unite with the parietals in old age. The interparietal suture is often obliterated; the interfrontal usually. There are no pre- or post-frontals, nor stylo-hyals; unless the vertical plate of the ethmoid represents the first named. I have not observed an interparietal, or Wormian bones. Ordinarily there is nothing to indicate that the mandible is formed of articular, angular, splenial, coronal, and dentary pieces; but its symphysis is imperfect, being only a synchondrosis, like the pubic and sacro-iliac.

The following are the commonly observed confluences of originally distinct bones:—Ex- and par- with basi-occipital, producing an "os occipitis" the spine of which remains separate; its neurapophyses meet above the foramen, but do not ordinarily coalesce. Basi-, ali-, pre- and orbito-sphenoid, resulting in an "os sphenoidale" which is not further complicated by coössification with the pterygoids. Mastoid with the otic sense-capsule (petrosal) forming the "petromastoid"; the separation of these elements from the squamosal and tympanic, and the absence of a stylo-hyal, reduces the ordinarily complex "os temporis"

to almost its simplest expression. Vomer with the olfactory sense-capsule (ethmo-turbinal); but the coösification is not perfect throughout. A spongy bone ("inferior turbinal") is attached to the inner surface of each maxilla.

The special characters of each of the bones above mentioned are now to be examined.

The *basioccipital* is only seen as a distinct bone in very young animals, although traces of separation from the neurapophyses persist during adolescence. Thus I find the suture, in an animal three-fourths grown, extending from the side obliquely inward and backward to the condyles, and exhibiting the part taken by the bone in the formation of the latter (about one third). The precondylar foramen is developed in, or just to, one side of this suture; another smaller opening exists a little internal to the last. The connection of the bone with the petrosal is slight; the most marked portion of the foramen lacerum posterius is just in front of the paroccipital. The forward extension of bone is simply a flattened plate, nearly four-sided, but tapering a little, abutting by a straight, transverse suture against the body of the sphenoid; longitudinally ridged underneath, smooth and slightly concave above, with an oblique groove alongside each anterior corner.

The *exoccipitals* rise from the back part of the body, develop the superior two-thirds of the condyles, and close over the foramen magnum, where, however, they do not ordinarily coalesce; the line of separation remained in all the skulls examined. They form a broad arch, whose longitudinal expansion is oblique, perforated on either side, at the base of the paroccipitals, and notched in the middle of the upper border for a descending process of the superoccipital; sometimes the upper border has a well marked prominence indicating the point where the superoccipital and mastoid come together.

I have never found the *paroccipitals* distinct from the exoccipitals. They form pointed conical processes of moderate length, directed downward, almost parallel with each other, roughened for muscular attachment. Their bases abut against the petromastoids; a deep notch separates them from the condyles.

The *superoccipital* is rarely, if ever, confluent with the exoccipitals. I have never seen it thus united. On the other hand, its bony union with the parietals is frequent, and with the "temporal bone," at the junction of the mastoid and squamosal, is sometimes seen. The lambdoidal suture, when not obliterated, is very irregular in direction, and mostly squamous in character, the outer surface of the superoccipital being bevelled for some distance. The superoccipital is a triangular pyramid, with an excavated base and sides: the concavity of the former being for the accommodation of the brain, and of the latter for muscular attachments. The excavations of the sides are virtually produced by the elevation of the occipital crest, which forms a segment of a circle from side to side; and by the beginning of the sagital crest, which runs directly forward from, and at right angles with, the middle of the transverse crest. The thickness and solidity of the bone, however, is not entirely owing to these crests.

Confluence of the *basi-*, *pre-*, *ali-* and *orbito-sphenoid* takes early place, and, when perfected, results in the single complex bone ordinarily called by the collective name "sphenoid." I find no traces of separation of these four bones in the youngest specimens examined. As might be expected from its composite nature, the connections of the bone are numerous. The contiguous bones are:—behind, the basisphenoid, and more

laterally, the petrosal and squamosal (which separate it from the mastoid), and sometimes the malar: on either side, the parietal and frontal: before, the vomer, ethmo-turbinal, palatine, and pterygoid. There is no actual connection with the tympanic; the mastoid is still further removed. I have never found it confluent with either of these contiguous bones: its connection with the palatines is perhaps most intimate; with the pterygoids and petrosals loosest. Its frontal and squamosal sutures are the most extensive; but that with the parietal is of considerable length, since the squamosal does not lift the parietal far away from the sphenoidal ala—though it is difficult to say how much of the spheno-parietal suture is formed by the orbitosphenoid, and how much, if any, represents the union of the neural spine with its proper neurapophysis, the alisphenoid. The basisphenoid alone unites with the basioccipital: the alisphenoid alone with the petrosal and squamosal; the orbitosphenoid with the frontal. Junction with the palatines is through three of the elements of the sphenoid: the ali-, orbito- and pre-sphenoid; union with the former being effected by the "pterapophyses" to be presently noticed: the sphenoidal relations of the pterygoids are almost wholly brought about by the same means. The articulation of the sphenoid with the basioccipital and vomer respectively is simple abutment of the thickened, squarely truncated extremities of these bones; that of the palatines and pterygoids is the lateral apposition of elongated processes; that with squamosal, parietal and frontal is the true, squamous suture, most decided in the latter case, where the orbitosphenoid very extensively overlaps. When the alisphenoid reaches the malar at all, it is a simple touching of the tip of its slender, lateral, articular process. Junction with the petrosals is imperfect and irregular.

The compound "sphenoid bone," thus made up and related, presents a stout, flattened "body," tapering from behind forward, distinguishable from the "wings" by its shape and solidity, and separated from them by grooves, ridges and foramina, apparent both above and below. The under surface is smooth; on either side are seen, from behind forward, the termination of the foramen lacerum, medium: two foramina looking forward and outward, separated by a slight bony bridge, the posterior opening leading backward by a groove into the foramen lacerum, and forward into the sella turcica: the anterior, which is the larger, curving inward and communicating with its fellow below the sella: the groove separating the pterapophyses completes the lateral boundary of the body. Inside, the body presents a deep hemispherical or hemiellipsoidal excavation, the sella turcica, on either side of which (but really in the ala of the bone) is the entrance of the foramen rotundum, now a long canal, that opens just outside the root of the pterapophysis. More anteriorly the body is bounded on either side by a deep semicylindrical canal, which conducts the optic nerves out through the foramen lacerum anterius.

The alisphenoidal part of the bone stands away from the body, on nearly the same horizontal plane, having but little upward inclination; and supports three very noticeable processes. The most posterior of these is a moderately large bulla ossea, or conch, in subserviency to the acoustic organ. It is a hemiellipsoid in shape, its convexity looking forward and downward, its large opening directly towards the tympanum. It is small in size compared with that occurring in some marsupials. Besides its physiological relation to the organ of hearing, it serves to complete, internally, the irregular parapet surrounding the fossa in which the delicate tympanic hangs suspended: the other minarets being the paroccipital, mastoid and zygomatic process of the squamosal. The petrosal lies along its

inner side; its outer side is in relation to the glenoid cavity and condyle of the jaw; at its inner base is a large foramen, sometimes, however, only a groove continuous with the foramen lacerum, from deficiency of the bony trabecule completing its periphery.

Perhaps the most interesting point connected with the sphenoid bone is the share it takes in the formation of the glenoid cavity, by means of a long, sharp-pointed "articular" process of the alisphenoid, which runs along the inner and anterior margin of the glenoid cavity, and usually reaches to the malar. This formation decidedly augments the transverse diameter of the glenoid, and a considerable part of the mandibular condyle plays upon the expanded and slightly concave under surface of the sphenoidal process. The latter, however, lying wholly in the general plane of the joint, does not afford an anterior wall of abutment for the condyle, like that furnished behind by the downward extension of the squamosal. The extent of the alisphenoid thus appropriated by the squamosal, perhaps explains why so much of the sphenoparietal suture is made by the orbital plate of the bone alone. This structure of the glenoid obtains in many, if not most, marsupials.

Anteriorly the sphenoid sends off on either side a long attenuated pterapophysis, which diverges from its fellow as it proceeds forward. These slender prongs reach as far forward as the termination of the bony palate; forming the main connection of the pterygoids with the sphenoid, augmenting the connections of the latter with the palatines, and forming part of the wall that laterally bounds the vestibule of the posterior nares.

Absence of a stylo-hyal, and non-confluence of the petromastoid, leave the "temporal bone" to be represented by the *squamosal* alone. There being but a small vacuity in the cranial wall to be filled by the squamosal, the greater part of this bone is devoted to the formation of the back part of the great zygoma, and the support of the mandible. The zygomatic process at first stands out at right angles with the squamous portion and then curves forward, expanded vertically, to effect extensive overlapping suture with the malar. The root of this process is thickened transversely for the site of the glenoid cavity; it sends downward a stout process to form the posterior wall of the articulation, and presents inwardly a rough, irregular projection for the alisphenoidal suture. The squamous part of the bone takes but small part in the formation of the wall of the encephalon, and less than appears upon viewing the skull outwardly, in consequence of the extent to which it overlaps the parietal. The posterior border of the squamosal is somewhat thickened and rises in a prominent ridge, which is the lateral downward continuation of the semicircular occipital crest. The termination of this crest represents the postero-lateral corner of the skull, in which the mastoid scarcely takes part, being small, and wedged in between the squamosal and the ex- and par-occipitals; separating the former from the last two. Above, the squamosal comes in direct relation with the super-occipital. A prominent ridge from the upper border of the zygomatic process connects the latter with the squamo-occipital crest, and overarches the otocrane. The fossa in which the parts of the ear lie is represented, in the lateral view, by a wide and deep notch between the glenoid process, and the termination of the occipital crest. Two large foramina are situated in the notched part of the squamosal. A well marked groove, extending along the inner aspect of the back part of the squamosal, is converted into a canal (venous) by a corresponding groove in the surface of the closely apposed petromastoid.

Confluence of the "mastoid process" with the otic sense-capsule results in the *petromastoid*, a small, hard, very irregularly shaped bone, firmly wedged in between the

alisphenoid and basi-occipital before, the squamosal and ex-par-occipital behind, with an anterior prolongation that just touches the basisphenoid, dividing the fissuræ laceræ posteriores et mediæ from each other. It always remains distinct from the surrounding bones. When *in situ*, but little appears on an outside view; viewed from within, it is seen to take a large part in the wall of the brain-case, presenting a smooth, sub-triangular surface, indented with a very deep, conical, cerebellar fossa, below which is the conspicuous opening of the internal meatus. Most of the superficies presents a very irregular roughened surface, closely appressed to the thickened root of the squamosal, with a venous canal running across it. The part that lies external, between squamosal and occipital, is smoother, being only slightly roughened for muscular attachment. The petrosal part proper appears, viewed from below, as a small, tapering piece of bone, with a swollen base, this convexity expressing the dome of the "whispering gallery" into which the interior is sculptured. But the description of the internal structure of the bone rather pertains to an account of the organ of hearing, than to the subject of the present memoir, and must therefore be omitted.

The *tympanic* is a delicate little oval ring, incomplete at part of its circumference, like a horse shoe. It is not bullous, and has no bony attachment with the rest of the skull. It supports the auditory ossicles, one of which is anchylosed with it. There are no decided angles or processes; but a noticeable groove for the membrana tympani, and another representing the confluence of the ossicle; the latter adds considerably to the tympanic half-ring, strengthening the slender, spicula-like prong; it is applied to the outer periphery, terminating by a somewhat thickened, rounded extremity; at the free end bent abruptly upon itself, in the plane of the tympanum, and extending, as the handle of the malleus, almost across the space to the back of the ring, as an extremely delicate spicula.

The *parietals* finally coalesce with each other along the median line; but in most specimens the sagittal suture is retained. The contour of the bone is very irregular; all the sutures except the sagittal are strictly squamous. The anterior margin overlaps the frontal bone for a great distance; the posterior, the super-occipital, but to less extent; conversely, the lower border is overlapped by the sphenoidal ala and the squamosal. Viewing the articulated skull from the outside, the parietal seems only joined below by the orbito-sphenoidal and squamosal plates; but, on removal of the latter, the posterior portion of the margin is seen to effect junction with the alisphenoid itself. At least, such is my impression from consideration of the parts of the sphenoidal ala, most properly to be regarded as ali- and orbito-sphenoidal; for the spheno-parietal suture extends to the base of the sphenoidal process that enters into the mandibular articulation. The parietal bones are thin — almost diaphanous; internally they exhibit a decided hollowing, whose concavity is greater than the outside convexity of the bone; the meningeal vessels impress well marked grooves along the posterior border of the vitreous table; the falx cerebri a single longitudinal one along the median line. The inner table of the bone is of much less extent than the outer, in consequence of the various extensive squamous sutures of the latter: there is little diploë between the two; its texture is coarse, with large interstices. There were no inter-parietal bones, nor ossa Wormiana, in any of the specimens examined.

Even in young individuals, in which the sagittal suture is perfect, there exists only a trace of the frontal suture; and this is speedily obliterated. The confluent *frontals*, taken as one bone, present a remarkable shape. Only a small part is devoted to the pro-

tection of the brain; the rest forms the roof of the nasal, and the inner wall of the orbital, cavities. The point of greatest constriction of the brain-case is in the frontal bone, just in advance of the overlapping of the border of the parietal. The greatest width of the cranial part of the bone is much narrower than the nasal part; its depth is equally as much less. While the cranial cavity of the bone will barely admit the tip of one's forefinger, the nasal will contain nearly the whole of the first segment of the thumb; the former is nearly cylindrical; the latter represents the frustra of two cones placed end to end; the strait between the cranial and nasal cavities is perfectly circular. The coronal suture, never obliterated, may be either directly transverse, or obliquely placed, inclining forward from above downward; it has no notches, or other notable irregularities along its course. The coronal, and all the other sutures around the frontal are strictly squamous; the several bones (parietal, orbito-sphenoid, maxillary, palatal, lachrymal and nasal) all overlap the frontal, except for about half of the fronto-palatine suture, when the reverse takes place. The outer lower margins of the bone are very irregular in their course, but in general terms, may be said to be direct from the lower corner of the coronal suture through part of the palatal, and thence to extend obliquely upward and forward to the point of greatest anterior extension, between which point and its fellow there is a very deep notch for the reception of the nasals, usually extending quite to the supra-orbital protuberance. The anterior part of the surface of the frontal is perfectly smooth, and nearly flat in every direction; it is bounded in front by the naso-frontal, and at the side by the fronto-lachrymal, suture. Behind, it is separated from the orbital and temporal surfaces by two prominent ridges, which, arising from the supra-orbital prominence, rapidly approximate as they proceed backward, meeting each other on the median line, uniting, and running backward as the frontal portion of the sagittal crest. The part of the frontal forming the temporal fossæ is irregularly concave; the orbital part is smooth, plane, and vertical; the two are separated by a slight ridge running from the supra-orbital protuberance to the sphenoid.

The interior of the frontal is perfectly smooth for its cerebral portion, the surface being only marked with two slight depressions for the rhinencephalon; the walls of the nasal chamber, on the other hand, are irregular, and marked in various ways. A strong ridge depends from the median line, marking the junction of the vertical ethmoidal plate, and dividing the interior into lateral moieties. The superior portion of the surface of each is hollowed for the reception of the upper turbinal convolutions; the lower portion (inner surface of orbital plate of frontal) is marked by several (four or five) longitudinal, horizontal lines, nearly parallel with each other, corresponding with the middle convolutions of the turbinate bones. There are a few other irregularities, not necessary to particularize, which, like those just described, relate to the convolutions of the spongy bones.

The *nasals* remain distinct from each other, and from the surrounding bones with which they are suturally connected. They are long and narrow, nearly straight, in mutual apposition along the median line. The anterior half is narrowly linear, the posterior has a lateral expansion; so that the fronto- and maxillo-nasal sutures enclose a diamond-shaped space upon the lower forehead; the naso-intermaxillary takes the place of the naso-maxillary suture for the anterior third of the bone. These sutures are squamous, the nasal overlapping the maxillary and intermaxillary. The superior surface of the nasals is smooth and nearly plane; the inferior aspect of the conjoined bones is a half-cylinder. The nasals

terminate in a point, which falls short of the end of the jaw; "rostral" bones are not developed.

The ascending ramus of the *intermaxillary* is wedged in between the nasals and maxillaries, extending about an inch upon the cheek, overriding the side of the nasal, and being in turn overlapped by the maxillary. The rami are curved, with the convexity outward, at first divaricating from each other to increase the calibre of the nasal aperture, and then somewhat approximating, and also each curling upon itself, as the alveolar borders come to meet on the median line in front. The palatal plate of each bone is almost divided into two longitudinal parts by an extensive fissure — the incisive foramen — which nearly reaches the alveolus. This foramen is not completed behind by the intermaxillary; it is simply a slit, so far as that bone is concerned. The median moiety of the palatal plate is an extremely long and attenuated spicula whose extent is not visible from below in the articulated skull, as the palatal plate of the maxillary overlaps it. The lateral moiety is much shorter, as well as broader; it terminates at the anterior border of the socket of the upper canine. The intermaxillaries are never confluent with each other or with surrounding bones. Each contains five teeth.

The *maxillary* is large, and has numerous strong processes. Its surface is smooth; the foramen appears just above the first or second premolar, opening upon a slightly depressed space, in advance of which is the bulging that denotes the insertion of the great canine. The nasal plate or process curves toward the nasal bone, and unites with the latter for about half its length, being anteriorly cut off by the intermaxillary; the posterior prolongation of this plate, in the form of a sharp pointed process, reaches the frontal. A deep excavation in the border of the bone, just below the process, indicates the seat of the lachrymal. Posteriorly the bone sends upward a large, stout, zygomatic process, for union with the malar, in a manner to be more particularly noticed under head of the latter. The alveolar border is strongly developed, particularly behind; it narrows anteriorly, and is deficient at the wide interspace between the first and second premolars. The palatal plate or process meets its fellow along a perfectly straight median line. Besides being nicked anteriorly to perfect the incisive foramen, it is deficient posteriorly, where the palatal plate of the palatine completes the bony roof of the mouth; and is, moreover, deeply fissured to form the posterior elongated vacuity, described below. Both upper and under surfaces of the palatal plate are nearly smooth; on the latter, however, a shallow but distinct groove may be observed running from the posterior fissure to the root of the canine. The posterior border of the bone, between the malar and palatine, is thick, smooth and concave; it is continued as a process just behind the last molar, taking part in the formation of the most postero-external of the ten openings in the bony palate. The share that the zygomatic process takes in the formation of the outer wall of the orbit is inconsiderable, though greater than appears on viewing the bone from the outside. The floor of the orbit — what little there is of it — is maxillar. The surface of this part of the bone is traversed by a groove, in which lies the maxillary division of the trigeminus, which is conducted by this means along the orbital floor into a bony canal, whose outlet is the maxillary foramen. The bone bears upon the inner surface of its ascending plate, the lower or anterior turbinal bone — a spongy convoluted mass, of extremely delicate texture, which nearly fills that part of the nasal chamber not occupied by the ethmo-turbinal. The maxillary is permanently distinct from all of its surroundings. The alveolus bears eight teeth

The *malar*, which is a large, stout bone, forms the greater part of the zygoma. In general form it is a little arched, a little curved outward, compressed, expanded vertically, and with extensive, very oblique sutural terminations. The anterior extremity chiefly unites with the maxilla by overlapping; but its extreme point is received into a slight pit in the latter bone, while the extremity of the zygomatic process of the maxilla is firmly wedged in a similar but larger depression in the malar itself. The suture is thus made remarkably strong. The posterior extremity of the bone is more irregular. A thin, scale-like lamina is appressed against the inside of the squamosal: the bone then continues, by its stout under border, to the glenoid cavity—its extremity being cupped to become continuous with the articulating surface. The lower margin of the shaft of the malar is concave, and presents a well marked, oblique bevelling for masseteric attachment. The upper margin is straighter, but is anteriorly cut away a little to afford a slight concavity, which is the lower margin of the bony rim of the orbit; and, still further forward, is broken by articulation with the lachrymal. The obtuse posterior termination of the bone gives a partial wall to the front of the glenoid cavity.

The *palatine*, though singularly irregular in contour, and curiously wedged in between several bones, can always be detached entire from its connections. It is essentially composed of three plates or processes. The orbital forms a great part of the inner wall of the cavity of that name, completed by the frontal and lachrymal. It is an excessively thin, delicate, osseous scale, nearly vertical, with a gently arched upper border, by which it bestrides, as it were, the contiguous border of the frontal, part over-, part under-lapping. A large foramen obliquely perforates the middle of the base of this upright lamina. An extremely attenuated sharp-pointed spicula of bone forms a horizontal process directly backwards, lying closely appressed upon the inner surface of the spheno-pterapophysis. This process augments what would otherwise be a slight spheno-palatine articulation. Its base gives off a narrow flange-like lamina of bone, projecting horizontally inward, serving to define the entrance to the posterior nares. The palatal process may be taken as the main body of the bone. This is transversely expanded, and sufficiently thickened to form the posterior termination of the bony palate. Its posterior margin is especially stout, and directly transverse, forming an acute angle with the lateral border. The inner border is apposed to its fellow of the opposite side. The anterior border is very irregular. Beside interlocking by semi-squamous suture with the maxilla, it is further broken and interrupted by a deep notch—the posterior margin of the largest palatal aperture; and another, more posterior and external, similarly encloses, with the maxilla, a second foramen. A large quadrilateral aperture exists wholly within the palatine, in front, near the median line; and there is a very minute perforation close to its posterior margin.

With the exception of the tympanics, and ossicula auditûs, the *pterygoids* are the smallest and most delicate of the cranial bones, and their connection with the skull is, if possible, even looser; it is almost impossible to preserve them *in situ*. They are excessively thin and fragile laminæ, inserted, by their longest edge, into the slight groove between the posterior prolongation of the palatines and the sphenoidal pterapophyses, nearly vertical in position, abutting anteriorly, by their enlarged extremities, against the termination of the bony palate. The presence of these flimsy little bones would seem to be merely in obedience to morphological law; they can subserve little, if any, teleological purpose. I do not comprehend the statement (Owen, Comp. Anat. II, p. 346) that the ptery-

goids "repeat the connections they present in birds." In this marsupial, at least, these bones, so far from having any connection with the tympanics, do not reach half way from the palatines.

The *lachrymal* is of large size, and forms a considerable part of the orbital wall. While its general shape is that of a thin, flattened, triangular scale, it has one stout process, sticking outward and backward, for articulation with the malar—the point of the process being thrust into a pit in the upper corner of the latter, like a tooth in its socket. The part of the bone that forms the rim of the orbit at the anterior canthus of the eye is thickened, and presents a perfectly smooth surface, of a semilunar shape, whose convex border fits the concavity in the margin of the maxilla. The large opening of the lachrymal duct appears in the centre of this surface, leading forward into a canal that runs the whole length of the bone before terminating in the nasal chamber. This foramen appears just outside the orbital rim—upon the face, rather than in the orbit itself. With the exception of the malar articulation above described, all the sutures are squamous; the edge of the bone overlaps both frontal and palatine, but is overlapped by the maxillary, and this to such an extent, that only its thickened central portion appears upon the outside. The inner surface forms part of the lateral wall of the nasal cavity; it is a little concave, and slightly impressed with a few irregular ridges and depressions.

The *vomer* and *ethmoid* (ethmo-turbinal—olfactory sense-capsule) may be most conveniently noticed together, as they form virtually one bone. In superficial extent it is one of the largest bones of the head; but it is very light and delicate in texture, the spongy masses forming by far the greater part. In shape it corresponds, in a general way, to the cavity of the nasal chamber, being something of a parallelopipedon, but narrowing supero-inferiorly from behind forward; similarly wedge-shaped transversely from before backward, and with a deep excavation at its upper posterior corner; thus resembling, except in the latter particular, the frustrum of a double wedge. It consists of a sufficiently strong vertical median plate (perpendicular ethmoidal lamina=coalesced prefrontals?) straight edged above and below, nearly vertically truncated anteriorly, and bearing upon either side the spongy convolutions, and bounded below, as by a horizontal keel, by the long, slender vomer, which coössifies throughout nearly all its length. The posterior lower corner is the only point where the bone acquires any decided solidity. At this point the bone runs out into a knob-like process, with vertical sides, convex base, and slightly concave superior surface; this process is received in, and exactly fits, the interspace between the anterior margins of the orbito-sphenoids, thus projecting into the cranial chamber and forming a protuberance, just behind the cribriform plate, upon which the rhinencephalon rests; it also arches over, and forms the roof of the passage over the presphenoid, converting the grooves on either side of this bone, by which the optic nerves escape from the cranium, into canals; behind, these canals inter-communicate, there being no median septum; but anteriorly they are separated by the articulation of the vomer with the presphenoid. This process is thus hidden within the cavity of the cranium; but the knob that is the truncated base of the vomer, and is borne upon its under surface, appears, upon viewing the outside of the skull from below, as a smooth bone, lying deep between the spheno-pterapophyses, abutting against the end of the presphenoid, and in direct forward continuation of the latter into the nasal cavity, forming the roof of the posterior nares. Further on the bone passes between, and is concealed by, the palatals—a faintly marked groove on either side of the

vomerine knob betraying the passage of the optic nerve into the orbit. The cribriform plate of the ethmoid begins at the anterior base of the inter-orbito-sphenoid process of the bone, and thence curves upward as it passes forward, in nearly the quadrant of a circle, thus finally gaining the top of the bone, and almost or quite touching the inside of the frontal. At its lower part the sieve is flat from side to side; more anteriorly and superiorly it is transversely concave. It is pierced with innumerable foramina, of varying size, but all small, very evenly distributed over its whole surface, with no indication of a median dividing line, except just at the antero-superior extremity, where there is a very small space free from holes, and also a slight projecting point—obviously a rudimentary crista galli. The lowermost foramina lead obliquely downward as well as forward; the upper ones directly forward; the different laminæ of the spongy substance having corresponding direction. It would be difficult, even were it desirable, to describe the details of the spongy convolutions: suffice it to say that they form large masses on either side of the median plate, corresponding in contour with the latter, and consist of very numerous exceedingly thin laminæ, mostly lying flatwise, and running from behind forward, partitioning each half of the nasal chamber into numerous small inter-communicating passages, each of which is lined by a duplicature of the common mucous membrane under which the olfactory nerves ramify. Upon the posterior and external part of the under surface of each spongy body the laminæ unite to form one continuous thin plate, that directly roofs that part of the nasal passage; more anteriorly, and toward the median line, the same surface comes in apposition with the spongy mass that is attached to the inside of the superior maxillary; and along this part of it there is no such coalescence of the extremities of the laminæ into one smooth plate; the under surface of the maxillary sponge (inferior turbinate bone) continuing forward the roofing of the nasal passage. Not as in those mammals in which the ethmoid takes part in the formation of the orbital wall, and in consequence develops, by external coalescence of its laminæ, a smooth surface ("orbital plate of ethmoid," *e. g.*, in man) the lateral surface of the spongy mass does not present a continuous osseous plate; it shows throughout the edges of the laminæ, penetrating its substance, and the duplicatures of the mucous membrane; and lies wholly inside the lateral plate of the frontal, vertical plate of palatal, and orbital plate of lachrymal, which three together form the inner (mesial) wall of the orbital cavity.

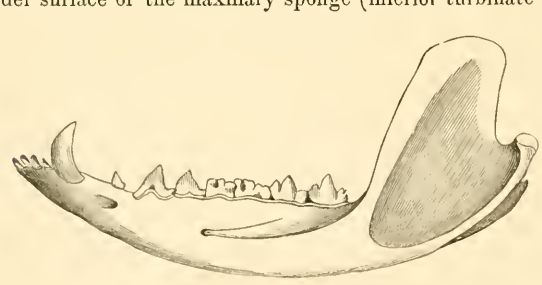


Fig. 7.

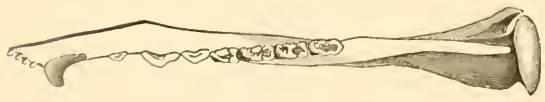


Fig. 8.

In the *mandible* (fig. 7, lateral view, left side; fig. 8, from above) all traces of the several bones of which it may have been originally composed, disappear at an early period; each lateral moiety was found entire in the youngest specimens examined. At the same time, the union of the halves always remains a simple synchrondrosis; and the jaw

readily comes apart without maceration. The rami meet at an acute angle (of about 30°); the symphysis is an inch long, very narrow, and almost horizontal; the course of each ramus is exflected, so that the two sides lie nearly parallel for this distance. The body of the bone is twisted upon itself, so that the alveoli, at first perpendicular, lean more and more outward from behind forward; the teeth, as a series, thus lie oblique to the long axis of the jaw; and while the molars are upright, the premolars slant a little outward, and the canine and incisors have a successively increasing outward and forward obliquity, (*vide* figs. 7 and 8). There are twelve teeth on each side. Taking the line of the alveolar border as the middle longitudinal axis of the mandible, the lower border of the bone represents an unbroken arc of a circle, from incisor teeth to condyle: the latter is situated much above the long axis just assumed.

There is no vestige of "an angle of the jaw," as such. The portion of bone that forms this part in placental carnivores is here inflected as it were, and appears as a sharp ridge, or plate, extending at right angles with the plane of the coronoid plate into the inter-ramal space toward its fellow of the opposite side. This ridge ends in a sharp pointed process, directed backward. The lower border of the jaw presents no noteworthy features until we reach the beginning of this remarkable process; there it becomes flattened, and transversely widened; a smooth, flat triangular surface being produced, mostly by the process just described, but partly, also, by a ridge of bone looking horizontally outward, and continued directly up to the condyle. The inner pointed process is separated from the corresponding side of the condyle by a deep and wide notch. A small and rather irregular groove leads obliquely from the notch to the outside of the condyle. The articular surface of the latter is greatly extended in its transverse diameter, and very narrow in the opposite direction. The coronoid process is enormously developed, seeming to virtually constitute the "ascending ramus of the jaw." In the articulated skull, it reaches above the superior margin of the zygoma. Its shape is liable to considerable variation with individuals; besides which, its general direction from above downward appears to change with age. In a young animal, I find that the backward obliquity is sufficient to carry the apex directly over the condyle; in adult specimens the coronoid is much more upright, as represented in the cut. The coronoid is very thin—almost diaphanous; the anterior border is thickened, and descends with a slight forward convexity to the main part of the jaw a little behind the last molar; the apical and posterior borders are very sharp; the former is obtusely rounded, the latter descends in a nearly straight (but sometimes sinuous or otherwise irregular) line a little below the level of the condyle, up to which it then curves, forming a well-marked notch. The inner surface of the coronoid is smooth, and continuous with the general surface of the jaw; the outer is roughened for muscular attachment, and forms a broad, shallow fossa, determined by the thickening of the bone along the anterior border of the coronoid itself, and the external ridge along the under border of jaw, leading up to the condyle. One would scarcely predicate, from the general contour of the mandible, the great force that the animal can exert with its teeth; but the enormous temporal and masseter muscles, acting upon the greatly expanded coronoid process, more than compensate for the disadvantages that result from the length and straightness of the jaw, and the position of the condyle. The dental nerve and vessels enter the jaw at a large oval foramen situated at the middle of the base of the internal angular process above described. A similar but smaller

foramen appears on the outside of the jaw, opposite the interspace between the first and second premolars; a third, still smaller, appears below the molar-premolar interspace.

c. Of the Skull as a Whole.—(Fig. 9, upper, fig. 10, under, and fig. 11, lateral, view).

Having treated of the skull as four modified vertebræ, and of its individual bones, it only remains for me to describe the whole resulting from the coherence or coalescence of the numerous parts. The teeth were considered in another connection.

Exclusive of the lower jaw, the general shape of the skull is that of an elongated cone, contracted at the base, flattened below, bulging at the sides, swollen across the forehead. There is nothing of the pear-shaped contour commonly seen in the skulls of carnivores, resulting from the expanded brain-case. The width of the cranial portion proper is produced mainly by the widespread zygomata, and the height by the sagittal crest. In consequence of the small size of the brain, in this as in other marsupials, the pericephalon forms but a small proportion of the entire skull—the greater part of which is appropriated to the formation of the nasal and buccal cavities, and the parts accessory to the movement of the jaws. The narrowest point of the skull (excluding the zygomata) is, in fact, across the anterior part of the cranium proper, where the hour-glass contraction is so great that the width of the cranium does not exceed that of the premaxillaries. The facial part of the skull is almost as long as the cranial. The greatest width across the zygomata is just half the total length. The height varies with individuals according to the development of the sagittal crest; in general it amounts to about a fourth of the total length. The same measurement applies to the height of the cranium proper and to the distance from the alveolar border to the fronto-nasal suture—the depth of the upper jaw thus surpassing that of the brain-case, since fully a fourth of the

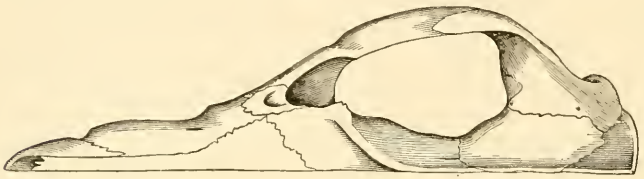


Fig. 9.—Skull from above.

Fig. 10.—Skull from below.

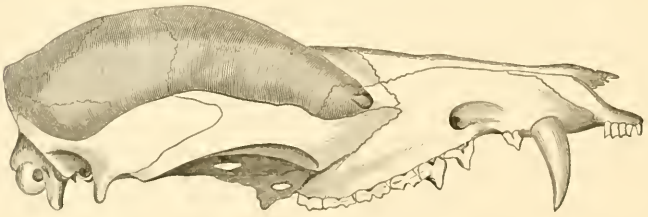


Fig. 11.—Lateral view of the Skull.

cranial depth is due to the elevated comb of bone. The inter-mastoid distance is less than the greatest inter-alveolar. The bony palate occupies about three-fifths of the length of the floor of the skull. The circumference of the constricted part of the cranium scarcely exceeds that of the muzzle measured just in front of the premolars. These various admeasurements display, very instructively, the predominance of the sensory over the ratiocinative faculties. The swollen and elongated face contrasts strongly with the contracted brain case. The expanded zygomata and enormous temporal fossæ, bounded by high, sharp crests, are as suggestive as the massive jaws themselves, with their long tushes. The shape of the bare skull betrays the cunning and ferocity of the beast, as plainly as these qualities are expressed by its physiognomy during life.

The base of the skull is semicircular in contour, continuously bounded laterally and above by the strongly developed occipital (no longer "lambdoidal") crest, the backward projection of which converts what would otherwise be a plane into a depression, all of which is roughened for the firm implantation of the nuchal muscles. This space is always traversed by the very irregular curved line, marking the junction of the par- and ex- with the super-occipitals and mastoid: and, except, perhaps, in very old skulls, by a second line, straight, vertical and median, at the junction of the exoccipitals over the foramen magnum. The latter is broadly oval in shape, widest transversely; its lower border is on a line with the straight edge of the base of the skull. The condylar protuberance is considerable; the condyles are lateral in position, looking outward, forward, and downward; superiorly they are separated by a wide interval, along which the rim of the foramen is thin and sharp; inferiorly the articular surfaces nearly touch each other. A deep notch separates them from the paroccipitals: the latter are stout, conical processes, projecting straight downward, till their apices reach the plane of the posterior molars. Their bases abut externally against the mastoid processes—two roughened, irregular prominences that complete the lateral corners of the semicircle. A small foramen perforates the posterior aspect of the mastoid, high up, opposite the most posterior root of the zygomatic portion of the squamosal. The condylar canals emerge from under the edge of the articular facets, in the depression between the latter and the paroccipitals. A minute foramen perforates the basioccipital on either side a little in advance of the condyles.

The superior aspect of the skull is abruptly bounded posteriorly by the transverse elevated occipital crests; laterally by the strong, wide-spread, curved and arched zygomata and perpendicular surface of maxillary and premaxillary bones. The sides of the cranium proper are depressed, roughened for the attachment of the temporalis and masseter, and present the hour-glass contraction already mentioned. They are only expanded and vaulted posteriorly between the roots of the zygomata. The surface is traversed by lines denoting the fronto–, spheno-, squamo– and occipito-parietal sutures; the latter is very frequently obliterated with age. The sides of the brain-case meet above, at an angle along the median line, where one of the distinguishing peculiarities of the opossum's skull is exhibited. This is the development of an enormous "sagittal" or interparietal crest or comb, extending unbroken from the crista occipitalis to the middle of the os frontis. The elevation of this crest increases with age, as usual, and is moreover subject to variation with individuals; beside which discrepancies, I think that I observe a difference dependent upon sex; the crest in the male being higher and thicker. The lateral moieties of the parietal portion of the crest usually remain separable, except in very old skulls. Owing to the

early coalescence of the frontals, this portion of the crest is usually found single. From the point of subsidence of the crest into the common coronal surface, two ridges diverge at an acute angle and run forward and outward along the frontal to the superciliary protuberances, marking the extent of attachment of the temporals to the frontal. The sagittal comb is thus forked, as it were, anteriorly.

The roof of the nasal cavities appropriates most of the superior surface of the skull; occupying all the surface anterior to the supraorbital ridges, and the forks of the parietal crest. This surface is everywhere smooth; the most marked irregularity of contour is a slight concavity on either side in the superior maxillaries, where the lower canine abuts. It is divided longitudinally for three-fourths of its extent from before backwards by the nasal suture—the neural spines never coalescing; there is no inter-frontal suture in adult skulls; the other sutures are the irregularly curved and arched naso-maxillary, the fronto-nasal, the naso-premaxillary, maxillo-premaxillary, and fronto-maxillo-lachrymal. A great part of the os lachrymale extends upon the superficies of the face; the opening of its duct lies outside the orbit. The only other opening upon the face is the foramen maxillare—situated just above the interspace between the second and third premolars, and of great size. The nasal aperture, of large size, is partially roofed over by the pointed projection of the two nasal bones, and completed at the sides and in front by the produced premaxillaries.

Vast temporal fossæ result from the constriction of the brain-case, the great outward sweep of the zygomata, and the imperfection of the bony orbits. The zygomatic process of the squamosal may be traced backward to its origin in the mastoid portion of the crista occipitalis as a prominent bony ridge, overarching the tympanic cavity. As soon as it fairly leaves the squamous part of the bone, it sends downward the strong process that forms the back wall of the glenoid, while at the same time its superior margin begins to rise. The superior margin of the zygoma is thin and sharp; its upward convexity is due as much to the expansion of the bone itself, as to the concavity of the opposite margin. The latter—the under border—is thickened, and has a well marked, oblique bevelling; its concavity is greatest anteriorly, where the malar bends downward to join the large out-standing zygomatic process of the maxillary. Posteriorly, the lateral view of the zygoma shows, at the termination of the malar, a deep excavation—the profile of the glenoid. The side of the zygoma is traversed by the oblique squamo-malar suture, which is never obliterated. Anteriorly, the superior margin of the zygoma is suddenly thickened, and becomes moderately concave—this portion defining the extent of the orbit. The structure and relations of the zygomatic arches are clearly displayed in the accompanying figures (9 and 10); these are such as would lead us to infer the nature of the animal's food, were we dealing with a placental mammal; but in the present order their indications are not so reliable.

The very imperfect orbits appear as parts of the temporal fossæ, having no bony wall posteriorly, and being only partially floored by the maxillaries. The contour is indicated externally by the above-mentioned concavity of the malar, anteriorly by the stout lachrymal, internally by a very slight superciliary ridge and more decided supraorbital protuberances. The lachrymal, frontal, and palatine make up the inner walls; in the formation of which the last named takes greatest part. This smooth, orbito-nasal septum is distinguished from the directly continuous temporal fossa by a slight ridge extending obliquely downward and backward from the supraorbital prominence to the orbitosphenoid, forbidding encroachment of the temporalis upon the orbit itself. The outer wall of the orbit seems to be formed

chiefly by the malar, on viewing it from the outside; but the squamous overlapping of the maxillary invades the inner surface of this wall; the maxillary has greater share in the production of the anterior, elongated, conical portion of the orbital cavity not occupied by the eyeball. This conical portion is the entrance to the canal whose external aperture is the maxillary foramen; and transmits the superior maxillary division of the trigeminus. The foramen of exit of the nerves that go to the eye are all situated behind the orbital cavity proper; the ductus lachrymalis itself is also outside of the orbit. The palatal foramen, however, is fairly within the orbit; it is circular, and of large size.

The glenoid fossa has the peculiar structure that is characteristic of many marsupials, being formed at the meeting of three bones—alisphenoid, squamosal, and malar. By far the greater part of it, however, is squamosal. The end of the malar is just nicked to complete the cavity antero-externally; a long, slender, horizontal, transverse process of the alisphenoid just touches the malar, and so forms the antero-internal border. The shape of the fossa indicates the nature of the articulation, which is strictly ginglymoid; there is no convexity of surface in the glenoid, nor such contour as to provide, however imperfectly, for lateral motion of the jaw. The fossa is directly transverse, wider than long, plane from side to side, and very concave antero-posteriorly. The concavity is produced mainly by the wide descending process of the squamosal, which affords an abutment for the mandible, preventing retraction. Anteriorly, there is only a trace of such a wall.

The bony palate is of great extent, reaching more than halfway from the incisors to the foramen magnum. It is carried backward beyond the last molars by the palatal process of the palatines, terminating with a thick, directly transverse margin, developing on either side a stout conical process, whence the sides slope obliquely forward and outward to the last molars. The palate is concave in all directions—most so from side to side, in consequence of the well-developed alveolar processes. It is longitudinally divided into halves by a straight line, denoting the apposition of each palatal, maxillary and premaxillary with its fellow of the opposite side; this line is never obliterated by confluence of these pairs of bones. There are ten palatal openings, symmetrically placed in pairs. The incisive foramina are two narrowly linear apertures, side by side, close to the median line, distinguishing the palatal processes of the premaxillaries from their alveolar portions. The perforations are closed behind by the maxillaries, which, however, take part in their formation by being nicked for about an eighth of an inch. The maxillary apertures, situated opposite the three last molars, are of large size (.66-.75 of an inch, or more, in length), and narrowly elliptical, or even linear, though their contour is frequently somewhat irregular. The class of osseous perforations to which the present foramina belong is obnoxious to irregularities of size and shape, and consequently can only be defined in loose terms. Most of the perforation occurs in the maxillaries; the palatals bound the posterior third or even half. Immediately behind these openings there are two smaller (but still large) perforations in the palatal processes of the palatines, placed close together, and generally presenting a four-sided contour. Externally, and a little behind the latter, the same processes of bone are again perforated, this time by oval foramina, situated close by the external border. Finally, there is a minute, circular foramen upon either side, just within the transverse, posterior termination of the palate. Notwithstanding these numerous fissures in the osseous roof of the mouth, the palate is much more perfect than that of some other marsu-

pials, as, *e.g.*, the *Perameles lagotis*, in which[1] "the bony roof of the mouth is perforated by a wide oval space extending from the second premolars to the penultimate molars, exposing to view the vomer and convolutions of the inferior spongy bones in the nasal cavity."

The remaining portion of the floor of the skull may be here passed over more rapidly, as the most of the points have been already noticed in speaking of the several bones that compose it. Its general contour is that of a lozenge, as far forward as the constricted part, beyond which it enlarges again. The central smooth tract is crossed by the line of separation of the basi-occipital and -sphenoid; rarely, if ever, obliterated. Just in advance of the most constricted point, a similar, but shorter, transverse fissure indicates the termination of the sphenoid; this is more liable to disappear by confluence of the following segment. On either side of the basi-occipital, the petrosals determine the extent of the oblique fissuræ laceræ. The moderately developed bullæ osseæ form smooth, convex protuberances just outside the petrosals; the entocarotid foramen lies immediately anterior, and a little internal; the foramina ovala et rotunda a little further forward; the optic still more in advance. The sphenoidal "pterapophyses" rise on either side to meet the palatals, partially forming the side walls of the conduit that leads into the posterior nares. These walls are completed by the thin, expanded falciform pterygoids, vertically lodged by their very delicate and attenuated process in a groove in the sphenoid pterapophyses. The auditory fossæ occupy the postero-external corner of the skull, appearing as deep notches between the articular processes of the squamosal and the mastoid, limited internally by the petrosals and sphenoidal bullæ. There are two oval foramina, side by side, in the outer part of the notch; just below them, the delicate tympanic ring is seen suspended at the entrance of the meatus auditorius.

2. The Other Vertebræ.

a. Cervical Vertebræ.—(Figs. 12 and 13). The neck-bones (which are seven in number, as in other marsupials, and nearly all mammals), form a strong compact pile, so closely locked together that little motion is possible except at either extremity. Fixation of this portion of the spine is effected both by large overlapping lateral processes, and by the enormous development of the spines of most of the vertebræ. Extension beyond a right line is only permitted at the base of the neck; twisting is mostly, if not wholly, confined to the atlas, and only an inconsiderable amount of flexion is attainable. Five or six of the vertebræ, indeed, virtually act almost as one bone, and mobility is sacrificed to stability. Nearly all the motions of the neck arise between the first dorsal and seventh cervical, where movement is very free, in compensation for the rigidity of the rest of the column.

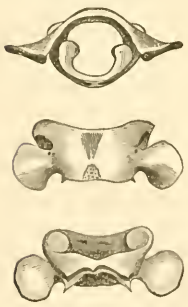


Fig. 12.
Three views of the Atlas.

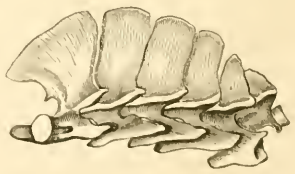


Fig. 13.
Six Cervicals, lateral view.

[1] Owen, Comp. Anat. and Phys., II, p. 346. The author considers the vacuities of the bony palate of marsupials —animals forming the transition from oviparous to placental vertebrates—as an approximation toward the defective condition of this part of the avian skull.

sation for its loss elsewhere. Rotation of the atlas around the odontoid is also very perfect. Need of fixedness in the cervical portion of the spine results from some of the habits of the animal, which roots, pig-like, in soft earth and decaying vegetation, in search of the worms, etc., that form part of its food. The great spinous processes, as well as the high occipital crest, are required for the attachment of the large muscles by which such actions are rendered easy. The flexion at either end that the column is capable of, undoubtedly has reference to the care of the contents of the pouch.

Each of the cervical vertebræ has peculiarities whereby it may be recognized; though there is comparatively little difference between the third, fourth and fifth. The following remarks apply to the conjoined bones as a whole, exclusive of the atlas: The neural spines together form a massive arch, culminating at the third bone, rapidly descending in front to the atlas, more gradually sloping behind to the seventh, which has only a rudiment. The middle portion of the arch is the heaviest, widest across, and most closely locked. The neurapophyses are short, thick, heavy and vertical. At the third vertebra they do not project laterally beyond the side of the spines, though they become thinner, longer, more oblique, and spread further apart upon successive vertebræ from before backward. They develop large pre- and post-zygapophyses, with very oblique articular surfaces, largely overlapping each other, and firmly interlocking. These processes together form a prominent serrated ridge along the side of the column, separated from the series of transverse processes by a wide and deep sulcus. The "transverse" processes are of great size, and remarkably expanded in their longitudinal axis. Their free terminal edges are placed a little obliquely, so that the posterior prolongation of each one overlaps the succeeding, and underlies the preceding, by which means the immobility of the column is augmented. The seventh alone does not present this longitudinal expansion of its transverse process. The pleurapophyses are confluent throughout the series, producing vertebrarterial foramina. Slight hypapophyses are given off by all the vertebræ, appearing as a continuous ridge along the under side of the centrums, which are otherwise broad and flat underneath. A transverse section of a centrum is nearly oval; of the neural canals somewhat horse-shoe-shaped; or rather stapeform, with its sides a little approaching below, and a slightly convex floor; highest anteriorly, widest posteriorly. The ordinary relative position of the vertebræ is that which approximates their spines most closely; hence the seventh, whose spine is deficient, surmounts, rather than directly follows, the sixth, guiding the cord, by a gentle curve, into the dorsal series. Were it not for this, the change in direction, resulting from the difference in the axes of the neck and back in the animal's ordinary attitudes would be at an abrupt angle. The entire series of vertebræ, viewed from the under side, presents a pyramidal figure, whose apex is the odontoid process; the bodies of the vertebræ, and their transverse processes gradually narrowing from behind forward.

The *atlas* (fig. 12) is notable for the great expansion of the di- and neur-apophyses. The latter form a broad, heavy arch, over the smooth surface of which the advancing and overlapping spine of the axis plays freely from side to side. The lateral processes form two large, thin, flat, subcircular plates, moderately pedicellate, reaching on either side far beyond the corresponding processes of other vertebræ, and serving as powerful *points d'appui* for muscular action. They have no obliquity, in the longitudinal axis, but extend a little behind the posterior margin of the neurapophyses. The so-called "body"

a little behind the posterior margin of the neurapophyses. The so-called "body" (hypapophysis) of the atlas, unlike that of some marsupials, in which it does not advance beyond the cartilaginous stage, is completely ossified. The ossification appears to take place at an early age, as I find the bony ring perfect in a specimen in which the epiphyses of the long bones are still distinct. The ring, unlike the broad neural arch, is slender and delicate. Within, it is scooped away for the lodgment of the odontoid, which appears but loosely confined, so far as lateral motion is concerned. The contour of the inside of the ring and neural arch together is, in a general way, circular; but on looking through the aperture, a slight hour-glass contraction is observed, dividing the canal into two parts. The upper conducts the spinal marrow, the odontoid revolves in the lower; they are of nearly equal size; the upper is wider and flatter. The constriction is produced partly by the little bony eminences that serve for the attachment of the check ligament; but more by the inward expansion of the well developed post-zygapophyses. These articular plates are raised above the general level of the bone, with their sharp, well-defined edges above; below they gradually subside into the articular surface for the odontoid process. The condylar articular facets appear as large, well marked depressions. There is no vertebrarterial foramen; the vessel merely grooves the bone as it passes by the root of the transverse process. Anteriorly, the neural arch is perforated on either side by a venous canal, running directly transverse, and opening on the outer surface into a deep, distinct groove that winds around the front of the base of the transverse process. Inside the arch, the canal terminates abruptly at the inner margin of the condylar facet, but varies in different specimens; sometimes it is little more than a simple perforation, terminating a long groove; in others, the greater part of this groove is bridged over by bone. In one individual I observed a difference between the two sides of the bone. The left presented the groove and simple perforation; the right, a long canal, whose bony arch was deficient in the middle, displaying the vessel after it had been once hidden. This interruption caused the most lateral part of the canal—that at the root of the transverse process—to simulate the vertebrarterial foramen in everything but position.

The neural spine of the *axis* is the remarkable part of that bone. It is an enormously expanded, upright lamina, thicker behind than before, reaching its greatest height posteriorly, where it rises vertically above the line of articulation of the next vertebra, and thence slopes downward and forward to reach the anterior border of the atlas. This forward projection of the spine lies upon the neural arch of the atlas, riding freely from side to side. The post-zygapophyses appear as two flaring ovals at the back part of the root of the spine, though really borne, as usual, upon the neurapophyses. The pre-zygapophyses seem situated upon the anterior projection of the body of the vertebra; they are stout, prominent processes, whose articular facets are well defined by a sharp border, except just in front where they appear more or less continuous with the articular surface of the odontoid process. The latter presents no special peculiarity, being simply a conical knob. The vertebrarterial canal is perfect. The greatly produced posterior prolongation of the transverse process projects outward, downward and backward; there is no corresponding anterior prolongation, such as exists in the other cervical vertebræ; this portion of the process subsiding into the body of the vertebra just at the termination of the arterial foramen, which it bounds below.

The *third* cervical is the opossum's "vertebra prominens"; the spine here reaches its

maximum of development in height and width, though wanting the antero-posterior expansion of that of the axis. It forms a massive, upright, four-sided pillar, slightly expanded at the top, and slightly grooved from top to bottom on its anterior and posterior sides, for the more complete interlocking of the contiguous vertebræ. The spine is perfectly vertical, and just as thick transversely as it is antero-posteriorly. The pre- and post-zygapophyses are alike in shape; their articular faces are in parallel planes, looking in exactly opposite directions. The transverse process here first shows an anterior downward and forward prolongation, as well as a posterior one, beginning the series of lateral overlapping and interlocking that has been already alluded to. The *fourth* vertebra is like the third in all essential particulars, but may be distinguished by its somewhat shorter spine, with a slight backward inclination and greater breadth in front than behind. The *fifth* again repeats the characters of the preceding, but the spine is much reduced, with a decided backward inclination, and narrower across than in the longitudinal direction; but it is still a pillar. The *sixth* is decidedly modified in two respects. The spine is a simple, short, pointed process, scarcely half the height of the preceding. Both zygapophyses are very prominent. The transverse process is unique in size and shape; neither that of the vertebra which precedes, nor that which follows, showing any approach to its peculiarity. This consists in a remarkable expansion downward and outward, producing a broad, thin, oblique plate of bone, lying within and below the line of the transverse processes of the other vertebræ. This plate is overlapped by the backward extension of the process of the preceding bone, but does not in turn overlap, or otherwise restrict the motion of the succeeding vertebra. The part of the process that corresponds to the overlapping portion of the other vertebræ, here stands out, with but slight backward inclination, appearing as a sharp spine springing from the back part of the root of the expanded plate, with the vertebrarterial foramen at its base. The *seventh* would scarcely be taken for one of the cervical vertebræ, were it not betrayed by the foramen. The spine is rudimentary, merely a little sharp point of bone, recognized by its position. The pre-zygapophyses project far forwards. The transverse processes have no overlapping by longitudinal expansion; they are slender spicula, projecting straight out sideways, perforated at the base. The neural arch is broad, both crossways and longitudinally, and projects back of the centrum, partly overlapping the arch of the first dorsal; its edge is nicked in the middle for the reception of the first dorsal spine. Such are the modifications of the several cervical vertebræ, resulting in the production, in this part of the spinal column, of the conditions noticed in speaking of the neck as a whole, and for the purposes there stated.

Dorsal Vertebræ. — (Fig. 14.) As in most marsupials, the dorsals are thirteen in number. The transition from the last cervical to the first dorsal is abrupt and well marked. At the opposite extremity the characters of the dorsal merge insensibly into those of the lumbar series.

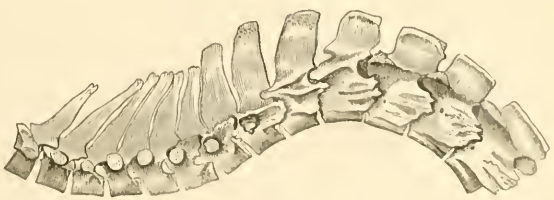


Fig. 14.—Dorsal Vertebræ.

The general tendency of the conjoined dorsals is to assume the shape of an open S, or rather italic *f*, the lower front part of which is completed by the upturned cervical series.

The back can be greatly hunched up, and the root of the neck brought into line with the pelvis. The "centre of motion" is at the last three dorsals and first lumbar, as shown by the verticality of the spines of these vertebræ. The spines of the several anterior dorsals are much inclined backward, in order to allow the abrupt upward curve of the cervicals in the usual position of the body. Great length of spine is necessary in these vertebræ, to allow of advantageous attachment of the muscles situated in the concavity of the S. The occasion for the great expansion of the transverse process of the sixth cervical is seen when the neck-bones are placed *in situ* with the dorsals. This cervical is at the point of greatest convexity of the S; its processes form prominent *points d'appui* for muscles upon the anterior aspect of the spinal column.

As I have said, the transition from the cervical to the dorsal series of vertebræ is abrupt, and this occurs, both from the configuration of the two contiguous bones themselves, and the direction of the two series of bones. The large cervical spinous processes almost disappear with the last of that series, to suddenly reappear upon the first dorsal, but with different shape. The spine of the first dorsal is a long, slender, tapering process, directed a little obliquely backward; but in spite of this backward direction, so sharp is the angle between the neck and back, that the spine, in some attitudes, may reach forward so that its apex almost touches that of the fifth cervical—overreaching the sixth, and more especially the seventh cervical. The dorsal spines increase in length and obliquity of direction to the third vertebra, after which they begin to shorten and to stand more upright. The occasion for their greatly attenuated form is found in the fact that they project into the cavity of the sigmoid curve that the back here makes, and must therefore be capable of being packed in less space, else this concavity would not be attainable. Their slender spinous figure is preserved to the sixth, where they begin to thicken, and have, on this and two or three succeeding vertebræ, somewhat the massive pillar-like figure of those of the middle cervicals. They are thickened, widened and shortened on succeeding vertebræ, until the last has little or nothing to distinguish it from a lumbar spine. In this and in all other features the last dorsal is so much like the first lumbar that its being costiferous is almost its sole peculiarity.

The transverse process of the first dorsal is like that of the last cervical, but much stouter, and bears upon its apex a very distinct facet for the rib. This process grows shorter with successive vertebræ, and only retains the same general physical character as far as the eighth, beyond which it begins to be subjected to the modification of form that culminates in the lumbar series. There is a corresponding modification in the vertebral extremity of the ribs, which no longer articulate with the spine by their "tubercles"; in fact it is hardly possible to recognize "head, neck and tubercle," on ribs behind the eighth pair. As will be seen presently, the transverse processes of the lumbar vertebræ are expanded and mutually overlapping, almost exactly as in the cervical series. Something of this obliquity and longitudinal expansion is the modification that the transverse processes of the five posterior dorsals undergo; but the development is not sufficient to produce decided overlapping. Coincidently with this modification of the diapophysial elements, metapophyses began to be developed, increase in size to the last dorsal, and thence continue into the lumbar region. The articulations of the anterior dorsal lie directly in the axis of the spine, the articular facets of the pre-zygapophyses looking upward, and those of the post-zygapophyses downward. With succeeding vertebræ, obliquity, both in a

transverse and a longitudinal direction, begins, and increases to the last. With the cessation of the articular "tubercles" for the ribs, the pre-zygapophyses begin to be surmounted by an elongated, pointed process, which grows less acute, and at the same time broader and heavier with succeeding vertebræ. The neural arches are low, broad, and comparatively thin, in the anterior portion of the dorsal series; they grow higher, longer, and more massive with each successive vertebra, and the same may be said, in general terms, of the centrums themselves. The intervertebral foramina are largest anteriorly; they progressively decrease in size from before backward, and at the same time gradually slide from the directly lateral position they occupy at first, more to the front of the column, so that they look forward as well as outward. The body of the first dorsal has one full costal facet, the others two demifacets, the rib being implanted on the intervertebral fibro-cartilage, and only nicking the edge of the bone itself. The bodies of the middle vertebræ are perfectly smooth on their thoracic aspects, and very convex from side to side; those at either extremity are slightly ridged by rudimentary hypapophyses.

Lumbar Vertebræ.—(Fig. 15.) The first lumbar repeats the characters of the last dorsal, and there is little modification in the remaining five bones of the series. The fourth vertebra, counting from before backward, is the largest of the set; the bones diminish in size in both directions from this one. The flexibility of this part of the spine is considerable in every direction; the movement of extension beyond a right line is least; that of flexion greatest. Few animals, indeed, except man, can make the "small of the back" concave. The zygapophyses bear nearly vertical articulating facets; the post- are locked within the pre-zygapophyses. The two processes are on either side connected by an acute, longitudinal ridge, which divides the side of the column into a narrow, deep sulcus above, between itself and the spinous processes, and a rather broad, shallow groove between itself and the series of transverse processes; these grooves are filled by the two divisions of the muscles of the loins. As already hinted, the transverse processes are greatly expanded lengthwise, in a slightly oblique direction, and mutually overlap each other like those of the neck. They increase in size and obliquity from first to last. The spines of the vertebræ are lowest and thickest at the first; they grow longer, higher, and thinner to the fifth; this and the sixth retain the height and thinness of the spine, but the length diminishes. The bodies of these vertebræ are, upon their ventral aspects, very convex transversely, and moderately concave lengthwise. The massiveness of the lumbar vertebræ, and the extent of their several processes, correspond with the great size and strength of the lumbar muscles, whose power must be sufficient, with the aid of the abdominal muscles, to enable the animal to flex the body to regain an ordinary position when suspended by the tail. Origins of caudal muscles, moreover, can be traced past the sacrum into this region of the spine, in which is their initial force.

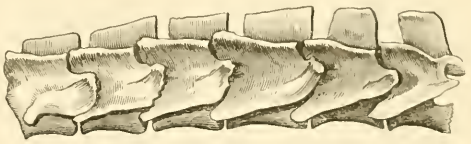


Fig. 15.—Lumbar Vertebræ.

Sacral Vertebræ.—(Fig. 16.) If the iliac synchondrosis be held to define the sacrum, this is composed of two bones; if serial anchylosis be taken as a guide, there are three sacral vertebræ. In adult animals, the equivocal bone is firmly united to the one preceding; but, at the same time, its physical characters are those of several succeeding coccygeals — as one

of which it may be best to consider it. The chief modification of lumbar characters that the two sacrals undergo is exhibited in their transverse processes, which thicken in every direction, and become confluent, leaving only a moderately large circular foramen at the base of their line of union. While the expanded and elongated transverse process of the last lumbar points obliquely downward-forward, and upward-backward, the reverse is the case with the similarly expanded and oblique, though thickened, sacral diapophyses. This change is necessary for coaptation of the osseous surface with the obliquely placed iliac shaft. The synchondrosial surface borne upon the confluent diapophyses is irregular in shape, somewhat approaching a narrow semilune. Union with the ilia is very imperfect; so slight is the force required to detach the sacrum, that some care is requisite in making a dried preparation of the pelvis. This loose-jointedness is of a part with that at the symphysis *menti et pubis*, among many of the cranial bones, the several sternebers, etc.; and is, in fact, one of the characteristics of the animal's skeleton. The spinous processes of the sacrals remain distinct from each other; they have the same shape as those of the last two lumbars, and incline slightly forward. Zygapophyses are perfectly developed on both of the bones, but they only subserve movable articulation with the last lumbar, in consequence of the anchylosis of the two sacrals, and of the last of these with the first caudal. The motion of the last lumbar upon the sacrum is quite free.

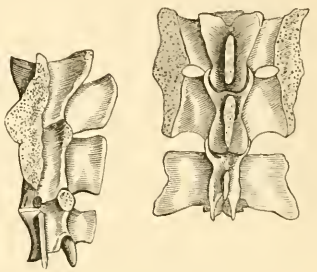


Fig. 16.—Upper and side views of Sacrum and first Coccygeal.

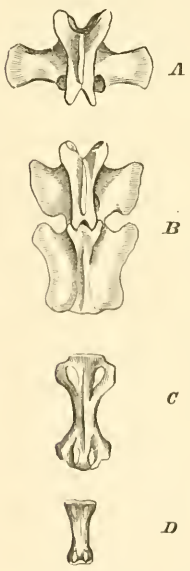


Fig. 17.
Coccygeal vertebræ: A, 2d;[2] B, 5th and 6th; C, 12th; D, 18th.

Caudal Vertebræ.—(Fig. 17.) Admitting the above mentioned questionable vertebra to this series, the tail is composed of twenty-three bones.[1] The adaptation of these bones to the prehensility of the member results in some interesting modifications. The first, as we have seen, is (always?) anchylosed with the sacrum; the remainder are freely movable, yet most of them — all beyond the fifth — have a different articulation, in which zygapophyses take no part. The series of articular surfaces is so arranged that the tail, when not in use, habitually assumes the shape of a note of interrogation laid horizontally, thus, ∾, as may be shown by boiling the bones from which the skin and muscles have been dissected, and allowing them to dry, suspended in the air by their proximal extremity. Part of the curling under of the tail in life is, however, due to traction of the flexor tendons. Near the root of the tail some downward convexity is possible; elsewhere, the member cannot be extended beyond a straight line without forcible bending. Lateral bending is everywhere more or less free; and particularly so towards the root of the tail; so that when the animal is squatting, the tail can be

[1] Owen (Comp. Anat. and Phys., II, p. 332), says "twenty-two." The same author assigns to another species of the genus—*D. cancrivora*—thirty-one. In this, therefore, as in other genera of long-tailed marsupials, the number of caudal vertebræ varies within wide limits among the different species; and in the same species a difference of one or two bones may possibly occur, as an individual peculiarity.

[2] First unanchylosed one.

curled around the fore paws. Considerable twisting, or rotation of the vertebræ upon each other, can be borne without inconvenience. The perfection of the "fifth hand" is brought to mind as forcibly by its bones, as by the admirably adapted set of muscles, the closely packed bundles of tendons, and their dense fascial and cutaneous envelopes.

The first caudal is nearly a repetition of the last sacral, except as to its transverse processes. These resume the thin, expanded, laminar character of those of the lumbars; but increase in lateral projection or length, and are horizontal, not oblique. The spinous process suffers marked diminution both in height and length; the pre-zygapophyses are anchylosed; the posterior ones, though small, bear perfect articulating facets. The under surface of the centrum is concave lengthwise.

The next four (second—fifth) caudals are similar to each other, and have the following characteristics: The spinous process becomes rudimentary with the first of them (second coccygeal), and disappears with the last (fifth coccygeal). The transverse are broad, long, thin plates, of a squarish shape, slightly constricted at the base; they call to mind the corresponding process of the atlas; their longitudinal extent or width increases, from before backward, coincidently with a decrease of lateral projection; that of the second coccygeal is longest and narrowest. The anterior articular are long, conical, flaring processes, completely embracing the post-zygapophyses; both bear perfect facets. The neural arches are very short, and already have greatly diminished the calibre of the neural canal. The centrums are long for their breadth; the disparity increases from before backward with successive vertebræ, at the same time that their under surfaces become more and more flattened.

The degradation of the vertebræ, already apparent, is suddenly increased, and becomes very obvious, by the modification of the sixth caudal, which is the first to decidedly assume the physical characters that are to characterize the rest. Its transverse process changes to a thin lamina, running the whole length of the bone, wider anteriorly than behind; the body itself of the vertebra appears as if it were merely a longitudinal thickening of this lamina along the median line. Anterior articulating processes are perfect, as hitherto, in the caudal series; but post-zygapophyses have become rudimentary, and articulation with the seventh is effected only by the centrum. The rudimentary neural spine is only indicated by a thin, low crest along the middle line. Neurapophyses, however, have not entirely subsided, so that this vertebra is still perforate; but the canal barely admits the passage of a bristle, and appears not to transmit a continuation of the neural axis. The neural canal of the fifth terminates at the distal extremity of the bone in a somewhat different manner from that observed in antecedent vertebræ; the neural arch, leaving the articulating processes, extending upward, and flaring outward, is separated by a deep fissure from the centrum along the posterior third of the vertebra, so that the canal has a lateral as well as a terminal opening. The seventh caudal is impervious, and in other respects completes the changes that began with the sixth; and successive ones are no longer, teleologically, vertebræ, but simply the phalanges of the opossum's fifth hand.

The remaining caudals resemble phalangeal internodes, both in appearance and function. The next succeeding half dozen are longer, both absolutely and relatively to their width, than any of the preceding ones; but they gradually shorten, and more rapidly become attenuated. The transverse processes appear as a ridge on either side of the seventh—tenth, suffering constriction at the middle, so that the bones, viewed from above, present an

hour-glass contraction. On the remaining vertebræ, these processes are simply little lateral knobs, representing, on the sides of the bones, the rudimentary zygapophyses on top. From about the seventh or eighth, they take part in the articulation. Rudiments of both articular and transverse processes may be traced to the very last bone; but they are very insignificant in size beyond the fifteenth or sixteenth, and articulation is really effected, beyond the sixth vertebra, by the ends of the centrums themselves.

In this scansorial prehensile-tailed marsupial, as in the saltatorial forms of the orders, the remarkable feature of "hæmal arches" is found. The use of these singular arches is, beyond a doubt, the protection of the blood vessels from undue pressure. They only occur in those species in which locomotion is aided by the tail, as the kangaroo, phalangers and opossums. In the present species these arches begin between the third and fourth caudals and continue uninterrupted to the very last. These chevrons are perfect throughout the series—not presenting the separation of the lateral moieties that occurs with the terminal ones in some other genera. They are V-shaped, and situated directly at the articulation; the proximal ones are the largest, in general, and the rest successively diminish to the last; but the second one is larger than the first, and the only one that presents a large hæmal spine, directed backward. The first half-dozen or so have decided spines in the direction of the arches; the rest no more protuberance than necessarily results from the coalescence of the two crura of the arch. From first to last all are perforate, and transmit vessels. Beside defending the circulation, they give leverage to the powerful flexor muscles of the tail. The ingenious device of these hæmal arches affords a beautiful illustration of exceptional development to meet special emergency.

3. The Thorax.

The dorsal vertebræ having been already considered, it only remains to notice, in this connection, the ribs and sternum (fig. 18).

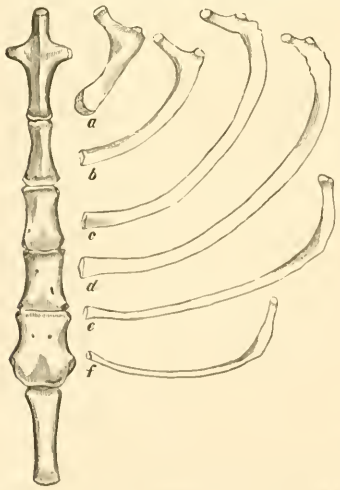


Fig. 18.—Sternum and osseous portions of several ribs; *a*, 1st; *b*, 2d; *c*, 4th; *d*, 8th; *e*, 11th; *f*, 13th.

There are thirteen ribs, six of which join the sternum, and three each other, leaving four free. The pleurapophyses alone are osseous; the hæmapophyses remain cartilaginous, or at most, had acquired but little bone-earth (and that only in the upper ribs) in the oldest individuals I dissected. The first pleurapophysis is very short—less than an inch long in well grown specimens—owing to the great contraction of the apex of the thorax; very stout, nearly straight, with a large tubercle, that appears as the real end of the bone, the neck being short and slender, set off at nearly a right angle from the main shaft, and bearing a slightly enlarged head. The ribs rapidly lengthen (*e.g.*, the third is more than twice as long as the first) to the sixth, seventh and eighth, which are about equal to each other, and longest; and then more gradually shorten to the last. Coincidently with increase of length, the curve of the shaft becomes greater, as does also the

twisting of the shaft upon its axis. The curve and twist are both greatest at the sixth—eighth bones; whence they diminish in both directions with successive ribs. The difference in the direction of the axes of the neck and shaft of a rib decreases from the first to the last; and, *pari passu*, the distinction between shaft and neck becomes less and less, till it is scarcely recognizable on the eleventh—thirteenth. The tubercle, very prominent upon the upper ribs, vanishes before the last is reached. The tubercles do not bear perfect articulating facets beyond the ninth, the following ribs only jointing with the vertebræ by their heads; and the fifth—ninth ribs bear the second facet upon their neck, rather than at the most prominent point of the tubercle. The intercostal artery only distinctly grooves three or four of the longest ribs. The sternal extremity of the first rib is a stout knob; that of each of the others is flattened and expanded—most so with the longest bones.

The sternum is composed of six pieces, the general shape of which is shown in the accompanying figure. The lowest piece is thin and narrow, almost linear, with a slightly enlarged base for articulation with the fifth; it is supplemented by an extremely large, broad, flat, "xiphoid" cartilage, with a rounded free border. The fifth is subquadrate, nearly as broad as long, and abruptly thicker and stouter than the sixth. The next three are successively narrowed and elongated; the fourth and third preserving their squarish shape, and remaining flattened; but the second, with a depressed lower part, is rapidly narrowed and compressed above, to fit it to the manubrium. The latter is cruciform, being sub-cylindrical below, widening on either side to bear the arms of the cross, and developing from its outer or under surface a median longitudinal crest, that is further prolonged above the cross-pieces to form an elongated process. The clavicles are loosely joined to the apex of this process through the intermedium of oval cartilages; the heads of the cross-pieces bear facets for the articulation of the first ribs; the other ribs articulate at the sternebral interspaces; each sternebr bearing at both ends a demi-facet for this purpose.

4. The Anterior Extremity.

Observations upon the general characteristics of the fore limb will be found elsewhere. There are forty-four bones in the scapular arch and its appendage, twelve of which are sesamoid.

Scapula.—(Fig. 19, *A*, *B*.) The general shape is quadrilateral, with three corners rounded off, and the fourth produced to support the glenoid fossa and coracoid process; the accompanying figure shows the details of contour. The posterior edge is thickened for muscular attachment; the upper and under borders are thin. The thoracic surface, without concavity, is smooth and slightly undulating. The outer surface is likewise smooth and flat, or with slight

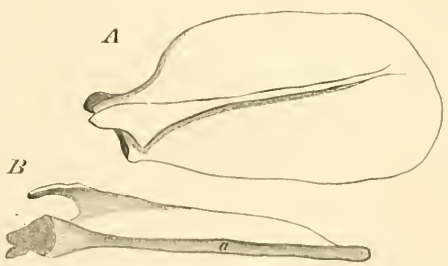


Fig. 19.—Scapula, from above and in profile.

concavity. The neck is short and wide; above, its margin is concave; below, straight, and in direct continuation of the lower border of the bone. The glenoid is an oval, somewhat elongated above, moderately concave in all directions, looking forward in the plane of the bone, and obliquely downward. It terminates above as a roughened tubercle, for attachment of the biceps; a slight notch separates this prominence from the coracoid. The latter is only a small knob, scarcely projecting beyond the margin of the glenoid, and bent obliquely or diagonally from the postero-superior angle to the antero-inferior, and terminating at the neck; the supra- and infra-spinal fossæ are of nearly the same superficial extent. The spine is perpendicular to the plane of the bone, rises higher and higher as it advances, and terminates in a large, flat, horizontally expanded, triangular acromion that projects over the glenoid, and is separated from the latter by a wide and deep notch.

Clavicle.—(Fig. 20.) The collar-bone is small and simple, with a single curvature, flattened, and slightly twisted upon its axis. Both extremities are slightly knobbed. Its acromial connection is very loose, and it has no true articulation with the sternum, being bound to the latter by long ligaments, in which a small oval cartilage is obliquely placed; this cartilage scarcely being of that sort usually denominated "interarticular."

Fig. 20.—Clavicle.

Humerus.—(Fig. 21.) The humerus is stout, of moderate length, and with one general curve forward. The most highly developed of its several well marked ridges, is that forming the outer border of the bicipital groove; it is sharp, extends more than half-way down the bone, and ends in a large, roughened tubercle for the deltoid. The groove itself is shallow, from lack of a well marked inner ridge, except above, where it forms a decided depression between the inner and outer tuberosities. The last of these is much the larger of the two, and is continuous with the deltoid ridge; but both are well defined. There is no proper "neck;" the shaft gradually thickens above as it curves inward to support a large and very convex head; the articular surface looks in the usual direction; its contour is somewhat triangular, the three corners corresponding to the two tuberosities and a backward prolongation. The condyles and their ridges differ from each other in size and shape; the outer is shorter and broader, runs up with a sharp border, which abruptly subsides to give place to a smooth, rounded surface; but a musculo-spiral groove is scarcely recognizable; the inner condyle is longer and narrower, with a straight, oblique, smooth, thickened border that bridges over the large oval foramen (*g*). The expanded intercondylar space is smooth and flat; its anterior surface presents a radial depression, but no decided coronoid fossa; posteriorly there is a well marked olecranoid cavity. The extremities of the condyles are thick and rough for muscular attachments. The lower extremity of the bone curves a little forward, and the articular surfaces look in this direction as well as downward. These present no special peculiarities; they are continuous with each other; both are convex in every direction; the ulnar reaches lower than the other, and terminates

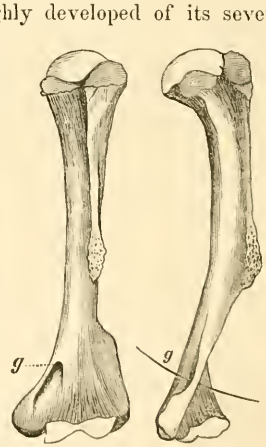


Fig. 21.—Left Humerus.

abruptly externally, instead of gradually subsiding. Certain minor differences aside, the resemblance of this bone to the human humerus is striking.

Ulna.—(Fig. 22.) Considerably longer than the radius, in consequence of the great backward prolongation of the olecranon and length of the conical lower extremity. The olecranon lies in the axis of the shaft so that the articular cavity appears cut out from the upper aspect of the latter. Below, the shaft is nearly straight and cylindrical; its upper half is much compressed, the posterior border presenting itself as a curved ridge; and the anterior aspect has also a slight ridge along its middle third, subsiding above into a smooth, oblique, depressed face, along which the radius lies in pronation. This space widens internally, and suddenly curves forward to form the anterior lip of the greater articular cavity; externally it expands still more, and runs out into a pointed eminence, forming the floor of the "lesser sigmoid cavity," in which the head of the radius rests. The two articular cavities are continuous with each other; the greater lies very oblique to the axis of the shaft. The coronoid process is wider and more prominent than the posterior lip of the facet; which latter only represents a small part of the whole olecranon. The pointed, conical lower end of the bone is received, and rotates, in a cup-shaped depression, between the cuneiform and pisiform; the facet for the radial articulation is obscure. (The outline gives the profile of the sigmoid cavity.)

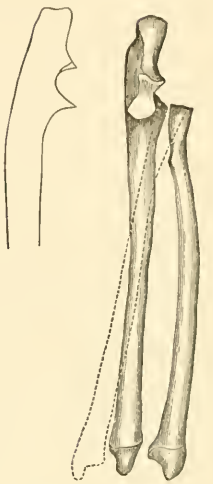


Fig. 22.—Left Ulna and Radius.

Radius.—(Fig. 22.) In the supine arm the radius lies very nearly parallel with the ulna; and the bones are only separated by a narrow interspace. The head of the bone presents the usual shallow circular cup for humeral articulation; continuous internally with a small convex facet that fits the lesser sigmoid cavity; rotation of the head, and, consequently, pronation of the arm, being perfect. The shaft is straight as far as the tubercle, where a gentle outward curvature begins, and thence continues to the lower extremity—enabling the bone to just clear the ulna during pronation. The stout enlarged lower extremity presents a broad, articular surface, that is prolonged, externally, into a conical process, like that of the ulna. This eminence overlies the scaphoid; the rest of the head articulates with the semilunar. (The dotted line indicates the radius in pronation.)

Carpus.—As in man, there are eight carpal bones, four in the proximal and four in the distal row; there are also two sesamoids on the radial side; the distal one of which articulates so extensively with the trapezium that it might be regarded as a fifth carpal bone proper of the second row. This sesamoid is wedged in between the trapezium and scaphoid; the proximal sesamoid is much smaller; it is merely a flattened oval nodule, ligamentously connected with the scaphoid and end of the radius.

The *scaphoid* has a large, flat, oblique facet for the radius, a cupped one for the semilunar, separated from a smaller, irregular facet for the trapezoid by a sharp process that extends between the semilunar and trapezoid nearly to the magnum. The relation between the scaphoid and trapezium is less intimate than that between it and the other bones just mentioned. The *semilunar* is a small concavo-convex triangle, with two facets upon its

convexity for the radius and scaphoid respectively, and one upon its concavity for the spur of the unciform; its distal border touches the magnum; its proximal border the cuneiform. It is thus in relation with five bones, as in the human hand. The *cuneiform* is wedged between the ulna, semilunar, unciform and pisiform; its ulnar facet is large and concave; that for the unciform next largest and concavo-convex; that for the pisiform plane, and continuous with the ulnar one. It merely touches the semilunar. The *pisiform* is the largest bone of this row, having a produced and knobbed free extremity, and looking, in fact, like an aborted metacarpal. Of its two facets, the large flat one is for the cuneiform; the smaller concave one combines with a similar one on the cuneiform to make a depression for the ulna. Its knob affords attachment and leverage to the *flexor carpi ulnaris*, and some muscles proper to the hand. The *trapezium* is very small, and irregularly triangular; it bears an oval depression for the head of the first metacarpal, a plano-concave facet for the trapezoid, and a little smooth surface for the distal sesamoid. It is scarcely to be called properly articulated with the scaphoid. The *trapezoid* is still smaller; its metacarpal facet only receives part of the head of the second metacarpal, which reaches the trapezium on one side, and the *os magnum* on the other; the bone articulates with the magnum, trapezium and scaphoid, but is excluded by the pointed process of the latter from the semilunar. The *magnum* is larger than either of the last two, but nevertheless smaller than the unciform; the metacarpal facet is divided by a sharp, vertical ridge into two parts, one supporting part of the head of the second metacarpal, and the other the whole of the head of the third metacarpal. The bone has an elongated facet for the unciform, a small convexity for the semilunar, and an irregular surface for the trapezoid; it also appears to touch the process of the scaphoid, and the side of the head of the fourth metacarpal. The *unciform* is the largest bone of the wrist, and supports the two outer metacarpals upon one facet, divided by a barely appreciable ridge; it is singularly irregular in contour, having a large hooked process that curves under the base of the fifth metacarpal, and a similar, but smaller and straighter prolongation between the cuneiform and magnum.

These ten bones together form a much arched wrist, concave in front from side to side, and correspondingly convex across the anconal aspect. The deep groove along the palmar surface is filled by the flexor tendons. The bones are very closely packed and interlocked; almost the only irregularity of superficies is that caused by the knob of the pisiform and hook of the unciform. The composition of the wrist is strikingly like that of man; the two sesamoids aside, there is really little difference to be noted, although none of the bones have precisely the same shape and mutual relation. The sinking of the ulna into the depression common to the cuneiform and pisiform, the exclusion of the trapezoid from contact with the semilunar, and the size and shape of the unciform and pisiform are among the chief differences displayed. The unciform and magnum appear to change places as regards the extent of metacarpal support they furnish, the former having here the largest articulating surface.

Fig. 23.
Heads of Metacarpals enlarged.

Metacarpus.—The five metacarpals are all of different lengths—the middle one being the longest, the second and fourth successively a little shorter, and the fifth much less than the fourth, which only slightly exceeds the first—the latter being the shortest. The four

finger metacarpals are notable for the enlargement of the heads, as compared with the bases; the slenderest point is just beyond the base, whence the bone gradually enlarges to the clubbed extremity. The thumb metacarpal differs in being larger at the base than at the head, and in having the constriction nearer the distal extremity. The second—fourth metacarpals lie as nearly parallel to each other as the difference in the size of their bases and heads will permit; these are both in contact, the former by articulation, the latter by simple apposition. The first, on the contrary, stands away from the others at an open angle; and this divergence is indicated as clearly by the articulating facet upon the side of the base of the bone, as by the outward shape of the hand. The facet in question is small and slightly cupped, and situated in a plane only a little oblique instead of perpendicular to, and directly continuous with, that for the carpal articulation—that is, upon the top of the head of the bone, rather than upon the side. It fits a little protuberance upon the corner of the base of the second metacarpal, and has motion in more than one direction, much freer than that enjoyed by the others. The head of the second metacarpal is divided by a vertical groove into two parts, with rather sharp and somewhat produced edges, one of which bears the facet for the first metacarpal just noticed; the other projects over the base of the third, so that the latter has carpal articulation only by half its head, the other half being received into a depression in the side of the head of the second. The head of the fourth, slightly convex and scarcely grooved, is flush with the corresponding half of the head of the third; the two are mutually apposed by a small plane facet. The head of the fifth is again flush with that of the fourth; it is made somewhat triangular by a small pointed process on its distal side, separated superiorly by a decided groove from the rather convex facet by which it articulates with the fourth. All these inequalities of the heads of the bones as one row correspond, it need hardly be added, to irregularities in the surface of the contiguous carpal row. The metacarpals are depressed along their shafts, being wider than thick; they are straight, or nearly so, but downward production of both bases and heads render their palmar profile concave; which arching, together with the concavity of the hand from side to side, produces a decided palmar hollowing. The heads of all the bones are very convex, wider than deep, and present a slight median vertical ridge bounded on each side by a corresponding slight groove; these inequalities are most marked on the first.

Phalanges.—There is scarcely any difference in the lengths of the second—fourth; the claw of the fifth reaches the base of that of the fourth; the claw of the thumb only reaches to the base of the middle phalanx of the index finger. The fingers have each three phalanges, whereof the first makes up most of their length, equalling, or exceeding, the other two and the claw together. The thumb has two; the proximate one is as long as the distal one and its claw. The ungual phalanx of each finger and the thumb is simply a little nodule supporting the claw—the thumb, unlike the great toe, being unguiculate like the other digits. The other phalanges have the usual configuration, and present no noteworthy peculiarities.

Sesamoids.—There are ten sesamoids in the hand—two small oval nodules placed lengthwise, side by side, beneath the metacarpo-phalangeal articulation of each of the five digits.

5. The Posterior Extremity.

In each half of the pelvic arch and its appendages there are forty-six bones; they are arranged as follows:—pelvic, four; femoral, one; in the knee, two (counting the rudimentary patella); crural, two; tarsal, eight; metatarsal, five; phalangeal, fourteen; sesamoids of the foot, ten. The eighth tarsal is the ossicle supporting the small cartilaginous spur. The patella scarcely deserves to be included in the enumeration; it consists at best but of specks of ossification; the other bone of the knee is the fibular fabella, which, though called sesamoid, is distinctly articulated with the fibula.

Ossa innominata. — (Fig. 24.) Bony union of the ilium, ischium and pubis occurs late, traces of separation being still distinct in adult specimens. The pubis forms less of the acetabulum than either of the other two; the ischium contributes the most. (Fig. 24, outline.) The cotyle is ample, both in depth and breadth, having a conspicuously raised, sharp, bony border around about three-fourths of its circumference; the remaining part of its margin (ischiatic and anterior) is much lower, without a sharp ridge, rising gradually in front to meet the pubic ridge, separated posteriorly from the ischiatic ridge by a narrow but deep groove — the ischiatic ridge terminating abruptly, with almost a process overhanging this groove. In the recent state this depressed part of the acetabular rim is made up with ligamentous tissue. In mature individuals there is no distinct articular ossicle, or "epiphysis of the ilium" like that described by Owen as existing in the immature Potoroo (Comp. Anat. Vert., II, p. 357), nor a second similar ossicle at the ischio-pubic symphysis. The synostcosis of the three bones at the acetabulum appears uninterrupted. Some irregularity of superficies that is apparent at the ilio-pubic junction may indicate the existence of such ossicle in specimens younger than those examined. The floor of the acetabulum is frequently so thin as to be diaphanous.

Fig. 24—Right half of Pelvis.

The contour of the innominate bone may be best gathered from the figure, which is drawn in the plane of the expanded ischium. It is spatulate in general shape, with the long, straight ilium for the handle of the spoon. The ischiatic tuberosity is not produced much backward of the axis of the ilium, nor notably curved in any direction, though a little so outward; it is obtusely rounded, and little more thickened than the main plate of the bone. The posterior or "ascending" ramus of the ischium inclines a little obliquely inward toward the acetabulum; its stout posterior border forming a ridge which mounts behind the acetabular wall to be continuous with the ilium above; its outer face is rendered concave, by the uprising of the cotyloid brim. The lower border of the ischium offers a gentle, unbroken curve to the pubic symphysis. This border, and the pubic symphysis, are both of great length; their union is indicated by a slight prominence, above which the symphysis mounts in a nearly straight line. On the pubic ramus, just at the symphysis, lies the smooth, narrowly oval prominence for the articulation of the marsupial bone; between this and the cotyle the pubis is slenderer than elsewhere. The obturator foramen is large, and sub-circular in shape—its chief irregularity of contour being produced by an

extension upward in front of the acetabulum. The ilium, after expanding to form its part of the acetabulum, narrows for a little, without decided ridges or borders, and then suddenly becomes sharply prismatic; which shape it preserves to its tip. The outer and posterior faces of the prism are perfectly smooth—the former decidedly concave: the inner (which is the broadest) is roughened in the usual manner for the sacro-iliac synchondrosis. The apex of the ilium is slightly clubbed, smooth and convex. The shaft is almost perfectly straight. With the exception of the sacral portion, the whole internal aspect of the innominate bone is smooth, and devoid of decided prominence. The two sides of the pelvis meet at the pubis, at an angle of less than 90°.

It is only necessary to allude, in this connection, to the great size of the pelvic outlet that obtains in this, as in other marsupials, compared with the dimensions of the fœtus at term. The disproportion is, however, less than that of some *Marsupialia salientia*; though greater than that which obtains in the Petaurists, where, according to Owen, the diameter of aperture is six times that of the fœtal head. Aside from other pelvic characters common to the order, (such as length, narrowness and flatness, extreme modification of ischio-sacral notch, extensive pubic symphysis, etc.) the length and straightness of the ilia, flatness of the ischia and pubes, and a general deficiency of well-marked angles or processes, such as an ilio-pubic or a backward, curved extension of the tuber ischii, are among the most notable points. The mammalian pelvis here finds very simple expression. The shape of the pelvis appears to relate mostly to the prehensile function of the tail, and the arm-like movements of the posterior extremities—to which latter it is peculiarly adapted.

Ossa marsupialia.—(Fig. 24.) The characteristic adjuncts of the marsupial pelvis here appear of moderate proportions, being neither very large nor very small, and of simple form. They are an inch and a quarter or half long, and ordinarily stand a little outward and forward, diverging from each other, their bases almost in mutual contact. In the accompanying figure, this obliquity would cause the bone to be much foreshortened were it drawn *in situ*; it is accordingly dislocated and laid flat in the plane of the rest of the pelvic wall. The shaft is flattened, smooth, without decided processes, very slightly curved (the convexity outward), slightly knobbed at the apex, spreading below into a laterally expanded foot. The margin of the base is oblique to the axis of the shaft, prolonged to meet its fellow at the symphysis pubis, and giving off externally a rounded knob or claw which lies upon, though not articulating with, the pubic ramus. The articulating facet is flat and narrowly oval, loosely fitting the tuberosity on the pubis already noticed. The joint is a simple hinge, permitting only flexion and extension of the bone upon the pubis; the amount of motion enjoyed is considerable. The mutual relation of the planes of the two articulating surfaces is such, that when the bones are drawn toward the abdomen their apices are approximated; and conversely.

The marsupial bones do not present any notable differences in the two sexes. In the male, they are thought to be subservient to the action of the cremaster, but as this muscle passes across them but little above their bases, the greatest outward inclination that they are capable of would but slightly affect the course, and consequently the traction, of this muscle. In the female, they must, I think, further the advantageous action upon the pouch of the muscles of the abdomen, even if they do not actually increase the power of the latter. Their relation to the proper muscle of the pouch may be more intimate and important.

They probably also tend to preserve the shape of the pouch, acting to this effect like the ribs of the thorax, though in far less degree. But their most important office is believed to be the increasing of the power or effect of the female cremaster, or "ilio-marsupialis," which muscle winds around them as around pulleys on its way from the haunch-bone to the mammary glands. Still this is only an assumption; for the strong suctorial power that the youngest animals have been found to possess, renders it improbable that voluntary muscular effort in compressing the glands on the part of the mother is called for. It seems highly improbable that they play any part in the act of parturition, as some have supposed. Owen regards them as homologically the hæmapophyses of the last lumbar vertebræ; and as teleologically belonging "to the category of the trochlear ossicles, commonly called sesamoids," being "developed in the tendon of the external oblique which forms the mesial pillar of the abdominal ring, as the patella is developed in the tendon of the *rectus femoris*."

Femur.—(Fig. 25.) The thigh-bone is long—over three inches in length—perfectly straight, stout, and nearly cylindrical. There is no decided "linea aspera," the posterior surface of the shaft being, instead, somewhat flattened, and presenting at the junction of its middle and lower thirds a tuberosity—almost a "process," which is rough for attachment of the adductor magnus. The shaft is slenderest at its middle, whence it gradually enlarges to the condyles. These have a backward extension; anteriorly, the mesial groove for the rectus tendon is broad and very shallow[1]; posteriorly, a very deep notch separates the two articular surfaces. The condyles are of nearly the same size; the inner one is the longest, and has the most backward and inward production; the outer is shorter and broader, and with a sharper external border. The lateral aspects of both are prominent, and rough for ligamentous attachments. The inner articular surface is narrow, and transversely flat or slightly convex; the outer is broader, and a little concave in the same direction. The head of the bone is far to one side of the axis of the shaft, held obliquely upward and inward at an angle of 45° upon a short, stout neck. A transverse section of the head and neck together would be in the same plane as a similar section across the two condyles—there being no twisting of the head either forward or backward. The articular surface is almost a hemisphere; the well-marked depression for the *ligamentum teres* is situated near the inner margin of the hemisphere. The constriction of the neck is slight. A slight ridge upon the postero-internal aspect of the neck soon rises into the sharp, well-marked, triangular *trochanter minor*, and suddenly subsides. This trochanter is situated upon the back and inner aspect of the shaft, nearly in the same plane as the latter. A stout ridge crosses the neck behind, running

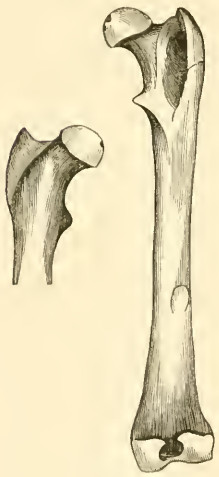


Fig. 25.—Right Femur.

[1] In consequence of (or causing?) the imperfection of the patella. According to Owen, "the intermediate anterior groove for the patella is well marked in the Perameles, where the patella is fully developed, but is broad and very shallow in the Phalangers and Dasyures, where the tendon of the rectus muscle is merely thickened, or offers a few irregular specks of ossification; and the corresponding surface on the Wombat and Koala is almost plane from side to side; in these marsupials and in the Myrmecobius the patella is wanting." The opossum is another instance of correspondence between this groove and the patella; exemplifying a law that perhaps has no exceptions.

obliquely upward and outward to connect the root of the small trochanter with the apex of the *trochanter major*. The latter is remarkably large and strong; its pointed apex rises fully as high as the top of the globular head, from which latter it is separated by a deep sulcus. The roughened surface of the trochanter to which muscles are attached, is of great extent, broad and obliquely truncated above, below gradually narrowing and losing itself in the shaft; but the downward continuation of this trochanteric line may be traced below the middle of the shaft, and chiefly gives the flattening of the posterior surface of the bone, already mentioned. Anteriorly, the expansion of bone between the trochanter and the neck is broad, smooth and nearly plane; posteriorly, the corresponding surface is interrupted by the inter-trochanteric ridge, and a remarkably large and deep "digital" fossa. The latter is of a narrowly oval shape, and is excavated to an unusual depth—being roofed over, as it were, by the backward expansion of the great trochanter.

The hip joint is well adapted to extensive and varied movements of the thigh—rotation, extension and abduction being specially favored, as usual with scansorial animals. The amount of motion permitted seems not very much less than that enjoyed by the shoulder joint, much of the mobility of the latter taking the place of the comparative stability with which a hip joint is usually endowed. This quasi-quadrumanous animal requires that the conditions of the proximal articulation of the fore and hind limbs should not be very dissimilar. At the hip joint we find beginnings of a series of modifications in the hind limb; which, constantly augmenting, culminate in the production of a member that is as much an arm as a leg.

Tibia.—(Fig. 26.) The fibula does not properly enter into the formation of the knee joint, the head of the tibia alone articulating directly with the femoral condyles. The articular surfaces present nothing specially noteworthy; the outer is decidedly the larger, and is a little convex in all directions; the inner presents a well-marked concave depression; the two are separated by an irregular prominence. The outer one presents, besides its femoral facet, a small, oval, transversely convex, smooth, articular surface, upon its outer margin, which is received into a corresponding concave facet upon the inner margin of the fibular head. This arrangement calls at once to mind the peculiar radio-ulnar articulation; and, in connection with certain peculiarities in the head of the fibula, to be presently noticed, has been used as an argument in favor of the homotypy of the ulna with the fibula and of the radius and with the tibia. But the tibia does not in this case rotate upon the fibula, but the reverse; and it is immaterial which bone bears the concave, and which the convex, facet. The "lesser sigmoid flexure" of the ulna here finds expression in a prominence instead of a depression; the concave lateral facet of the fibula is adapted to this prominence, as the convex lateral articulating surface of the radius fits the depression in the side of the ulnar head. The anterior tibial tuberosity (the "olecranon of the leg") is moderately prominent, and gradually subsides into the shaft of the bone. The latter is much compressed laterally; but its chief peculiarity is found in its bending along the middle of its course toward the fibula, as well represented in the cut. A "crest" may be traced along the whole length of the bone; but, contrary to the usual rule, it is sharper and more elevated below than above, owing to

Fig. 26.—Right Tibia and Fibula.

the gradual subsidence of the tibial tuberosity. The shaft, as a whole, is slender and weak, and presents no well defined sulci or ridges, except the crest just mentioned. The distal extremity enlarges gradually, and is extended into an obtuse conical process that forms the inner malleolus; the articular surface is very obliquely placed, irregularly triangular in contour, and nearly flat—its only concavity resulting from the downward extension of the malleolar prominence. While this malleolus is sufficiently produced to overlap and confine the corresponding side of the astragalus, the general configuration of the tibial articular surface insures great freedom of motion in the ankle joint.

Fibula.—(Fig. 26.) The distal extremity forms a perfect malleolus, as in other marsupials, and presents internally a facet for articulation with the tibia—this facet being continuous with that for the astragalus. Both the crural bones enter largely into the formation of the ankle-joint; and this distribution of the articulation of the astragalus between two bones, instead of its restriction mainly to one (the fibula), probably produces a great part of the whole difference in the relative degree of mobility enjoyed by the cruro-tarsal and radio-carpal articulations. Still the restriction of motion is not great; and the foot enjoys rotatory movements perhaps more than merely analogous to the pronation and supination of the hand. When the foot is strongly extended— and it can be extended till its longitudinal axis is directly continuous with that of the leg,—its movements of rotation are virtually, if not actually, those of pronation and supination. Did the tibia take but little less part in the formation of the ankle joint, it would become merely the pivot upon which the foot, borne upon the fibula, would rotate, and would exactly conform the conditions of the ankle to those of the wrist. The shaft of the fibula is very slender, almost perfectly cylindrical, and quite straight. The groove for the passage of the tendons of the peroneal muscles is but slightly marked, and scarcely traceable above the malleolus. At the upper end of the middle third the shaft begins to flatten and expand laterally to support a remarkably enlarged head. This expanded surface is posteriorly flat and smooth. Anteriorly it is transversely concave, and somewhat roughened for the attachment of the large peronei. The head of the bone is partially divided into two tuberosities, both irregular in contour. The inner one, which is the smallest, bears the oblique, concave facet already noticed. To the outer is attached a large "sesamoid" bone, to be more particularly described in speaking of the knee joint. The shaft of the fibula is not in contact with that of the tibia in any part of its length; both the proximal and distal extremities of the bone have, as we have already seen, loose articulation with the tibia. The decided inclination of the tibial shaft toward that of the fibula may relate in some way to the forearm-like movements of the leg; but it is not easy to see how these are favored by this means.

Knee joint.—The general mutual relations of the two bones of the leg are well calculated to increase mobility at the expense of stability; carrying out a purpose that began to be apparent in the structure of the coxo-femoral articulation. The resulting conditions are the opposite of those presented by the saltatorial marsupial genera, in which the tibia and fibula are united, or closely coaptated. The structure of the knee joint evidences the same plan, by allowing of other than strictly ginglymoid movement. Although this articulation is, as usual, femoro-tibial only — the fibula having no actual contact with the femur — yet the expanded fibular head, and the presence of the fibular fabella, contribute in some measure to femoro-fibular relations and movements that correspond to those

existing between the humerus and radius. Whether as cause or effect of the shallow anterior intercondylar groove of the femur, the patella is deficient, as in many other marsupials that have similarly constructed femoral condyles. In most instances, there is barely an indication of a patella in a slight, apparently cartilaginous, thickening of the extensor tendon; in some there is absolutely no trace of such a bone; in old subjects, one or several small specks of ossification, seeming to the touch like gritty particles, may be demonstrated. In this animal, at least, there is no "oleeranon of the leg," detached or otherwise, unless such process is represented by the "tuberosity of the tibia." The most noticeable feature of the knee joint is found in the presence of the fabella, developed in the outer lateral ligaments. This is an osseous nodule of an oval shape, with an enlarged base, surmounting the most external and posterior corner of the head of the fibula. It has a real articulation with the latter, a smooth, plane facet, subcircular in outline, being plainly shown upon the opposed surface of each bone. The presence of this ossicle may relate in some way to the rotatory movements of the leg; more obvious purposes subserved are strengthening and defending of the joint, and affording part of the attachment of origin of gastrocnemial and peroneal muscles.

Tarsus.—(Fig. 27.) The seven bones of the tarsus proper conform very closely, in individual characters and general disposition, to those of the human foot. The locking of the head of the second metatarsal between the two lateral cuneiforms obtains. Among the more prominent differences are, the shape of the articular surface of the astragalus, permitting freer motion at the ankle; the shape of the ento-cuneiform, producing the divergence and open articulation of the hallux; and the presence of the ossicle, attached to the ento-cuneiform, for the support of the rudimentary spur.

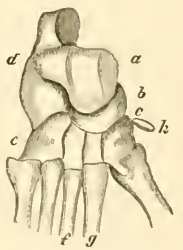


Fig. 27.—Tarsus and heads of metatarsals, 1 1-2 natural size.

The *astragalus* (fig. 27, *a*) is depressed, and of an irregularly triangular shape. The superior articulating surface — convex in every direction — receives the impress of both tibia and fibula. Along the middle is a slight antero-posterior groove, limited on either side by a slight ridge. This groove receives the head of the tibia, the internal malleolus resting against an oblique articular surface on the inner side of the groove; and the external malleolus resting upon a similar, though shorter and more convex, articular surface on the opposite side of the groove. The planes of these two lateral articular facets are but few degrees oblique to that of the median one; instead of being, as in many mammals, nearly perpendicular. As a whole, the large convex articular surface calls to mind that formed by the proximal row of carpal bones; and allows the same kind, and nearly the same degree, of motion that exists in the wrist. The posterior border of the astragalus is nearly straight; the internal one much curved; the antero-external one deeply excavated. The lengthened outer corner overlies and rests upon the calcaneum, near the middle of the latter; the anterior corner also rests in part upon the same bone, and extends to the cuboids, but is mostly received in, and presses upon, the navicular, transmitting pressure to the cuneiforms. The posterior corner projects freely backward and dips downward, to complete, with the os calcis, the groove for the passage of tendons behind the heel to the sole. The under surface is very irregular; there is a slight cupping for reception of a calcaneal protuberance, a decided convexity that fits a corres-

ponding depression in the os calcis, and finally a prominent ridge opposing the concavity of the navicular.

The *os calcis* (fig. 27, *d*) is very large and stout. It projects far back, terminating in a roughened knob for attachment of the tendo Achillis. Upon the plantar surface a prominent, stout, straight ridge runs along the median line from the posterior extremity. This ridge, with the help of a process from the astragalus, defines the groove for the digital flexor tendons, and divides the plantar surface of the bone into two large, smooth faces, rising obliquely on either side and spreading, or flaring, to support the expanded rotular aspect of the bone. The latter is very irregular, both in contour and superficies. It presents a prominent tubercle, which fits a facet on the under surface of the astragalus, and, more internally, a depression corresponding to an elevation on the astragalus. Anteriorly, the bone articulates with the cuboid alone (not with the navicular), by an oblique depressed surface.

In general terms the *navicular* (fig. 27, *b*) may be called hemispherical; but its contour is irregular, being moulded by surrounding bones. There is a deep depression behind and above for the astragalus, and a small, oval facet externally for the cuboid. The three cuneiforms are supported upon a continuous surface—the facet for the internal one being most distinct and decidedly convex; while the whole surface is convex from side to side. The internal and inferior non-articular surfaces are roughened for the attachment of ligaments.

The most noticeable feature of the *cuboid* (fig. 27, *e*) is the very deep, transverse groove that lodges the tendon of the peroneus longus. There is a deep pit upon the inner face of the bone, just in front of the facet for the navicular. The upper surface is nearly plane. Besides the convexity behind for the articulation with the calcis, the cuboid sends a sharp process to meet the plantar ridge of this bone. As usual, the bone supports the two outer metatarsals. The facets are scarcely separated by a ridge; that for the fourth metatarsal is the longest and most cupped; the other has a slight process overlying the base of the fifth metatarsal.

Of the three *cuneiforms*, the outer (fig. 27, *f*) and middle (fig. 27, *g*) deserve the name "wedge-shaped," being driven in and locked between the cuboid, inner cuneiform, navicular, and third and second metatarsals. The anterior face of the ecto-cuneiform is not flush, either with that of the cuboid or of the meso-cuneiform, but projects forward. The meso-cuneiform is the shortest and smallest of the three; it and the ecto-cuneiform both bear simple facets for the corresponding metatarsals.

The *ento-cuneiform* (fig. 27, *c*) is different from the other two, being noticeable for the acute process that assimilates it in physical character to the unciform of the wrist. The bone is of a very irregular shape, difficult of description, but may be said to have a thickened base, by which it articulates largely with the navicular and meso-cuneiform, and from which a stout, curved process is sent forward to overlie the base of the first metatarsal. The articulating surface for the latter is narrowly elongate, concavo-convex, with a strong ridge and deep sulcus, reciprocal to inequalities on the head of the metatarsal. The plane of this facet is turned away from the common plane of the others, its degree of obliquity expressing the divergence of the great toe from the rest. While the other tarso-metatarsal articulations are close, allowing little mobility, and that chiefly in one direction, this one is

almost as free as a metatarso-phalangeal joint, in the line of flexion and extension, and enjoys, moreover, considerable motion in other directions.

Besides these seven bones, there is an *accessory ossicle* (fig. 27, *h*) for the support of the rudimentary spur. It is a small conoidal bone, with an oval base, by which it is articulated with the inner aspect of the ento-cuneiform. It enjoys little, if any, motion. The spur is a small, oval, concavo-convex cartilage, lying closely appressed upon the muscle, over the base of the ball of the great toe, and covered by the common integument. Its position is indicated in the sole by the most internal of the tegumentary callosities. It is chiefly interesting as an indication of the well developed spur of one sex of the only lower mammalian order — the Monotremata. In the opossum the spur is not characteristic of sex.

Metatarsus.—The metatarsals are nearly straight, but a slight downward projection of the articular surfaces at either extremity gives some lengthwise concavity underneath, which, with the lateral convexity, produced by the shape of the extremity of the tarsus, produces a hollowing of the sole that is filled by the flexor tendons, lumbricales, and interosseous muscles. The second is the longest, the fourth is nearly as long, the third, fifth and first successively decrease in length; the last, besides being shortest, is much stouter than the rest, and depressed, being wider than deep. Its divergence from the others, and peculiar articulation, have already been noticed. The proximal extremity of the fifth is enlarged, and projects outside the cuboid; the articular facet only occupies a part of it. The heads of the second, third and fourth are small; that of the third, in particular, being scarcely wider than the shaft, though projecting considerably downward. Other minor differences in the heads of these three metatarsals need not be particularized.

Phalanges.—The four lesser toes have each three phalanges, the first of which is long and slender, surpassing the other two together; the third is simply a small, compressed, somewhat falciform ossicle supporting the claw. The hallux has but two phalanges, of which the last is a small nodule, bearing no claw. This toe terminates in a rounded clubbed extremity, upon the superior surface of which the place of a claw is indicated by a curved groove in the integument. The articulations of the phalanges with the metatarsus, and with each other, offer nothing peculiar.

Sesamoids.—The metatarso-phalangeal articulation of each of the five toes bears two sesamoids upon its plantar aspect. They are rather large, oval, placed side by side, their long axes parallel with the axes of the toes. Those of the great toe are embraced by the tendons of the *flexor brevis*; the others, by the *interossei*. Their presence is not invariable. The sesamoids of the knee joint have been already noticed.

PART II.—THE MUSCLES.

The following account of the muscles is designed to embrace descriptions of all those belonging to the general system. Most of the proper muscles of particular organs, as, *e.g.*, the eye, ear, larynx, heart, etc., and all those of unstriped fibre, are omitted; such being regarded as more properly falling in the province of a special treatise on these parts. Some, however, are noticed in considerable detail; particularly the muscles of the perinæum and genital organs.

An arbitrary division of the body into muscular "regions" being not entirely commend-

able, nor even practically convenient in many cases, a somewhat different, and perhaps more natural, method of grouping the muscles is followed. It is essentially similar to that lately proposed in my treatise on the Myology of the *Ornithorhynchus* (Proc. Essex Inst., vi, Mar., 1871, p. 127), although lacking some of the details of the latter, which I was led to adopt after the manuscript of the present memoir had passed out of my hands.

Muscles of the Head.

The general muscular envelope of the head and neck may be most conveniently considered here, in connection with the muscles proper to the cranium. Other muscles attached to the skull fall naturally into a different division.

Panniculus carnosus.—The entire head and neck are enveloped in continuous layers of muscular tissue, of somewhat complicated distribution. Although the platysma myoides, occipito-frontalis, and some other muscles of anthropotomy, together with some that are not recognized in man, are included in this general envelope, it may without violence be described as a single muscle, under the above name, with the following structure and disposition:—

A plane of muscular fibres begins over the shoulder and breast, and along the median line of the back of the neck, directly beneath, and intimately adherent by cellular tissue to, the skin. These fibres are the most superficial of all; and will be removed with the skin, if due care be not taken. They proceed forward, those of the side of the neck inclining toward the middle line of the throat, and there meeting those of the opposite side, surround the ear and eye, running a little way upon the former, meet along the median line of the top of the head, and finally end by insertion along the border of the orbicularis oris. This plane is continuous over the whole of the surfaces just pointed out; but its extreme thinness, even in the most muscular subjects, its intimate adherence to the skin, and the varying direction of its fibres in different places, render it difficult to trace in its entirety.

Beneath it lie two other planes of fibres, partially distinct, partially blended with each other and with the foregoing. One of these begins over the upper part of the breast, and runs straight up the median line of the neck, in apposition, or rather in direct coalescence with, its fellow of the opposite side, the two together forming a thin band an inch or more broad. At a point about opposite the angle of the jaws, the muscle widens by an outward sweep of its fibres; thence, nearly to the symphysis, the direction of the fibres is transverse. They form a transverse plane, each joined to its fellow along a median longitudinal raphé lying between the plane first described and the digastrici; mounting upon the side of the head, over the masseter, and becoming lost upon the temporal fascia. This appears to be the true platysma.

The third plane of fibres, although properly a cutaneous muscle, has a very distinct origin, not from the skin. It arises from the ligamentum nuchæ, from the occipital crest to a point opposite the apex of the scapula, just external to the trapezius, which it overlies. It forms in the neck a broad definite plane of fibres, at first proceeding directly transverse, and afterward inclining obliquely forward, as it approaches the median line in front. It loses itself, on the front of the neck, in the general envelope first described. At the back of the head the anterior border of this muscle first sends a slip up the ear, as will be more

particularly described presently, and then spreads forward with a nearly longitudinal direction of its fibres, over the temporal fascia, covering the latter from the parietal crest to the zygoma, on a line between the ear and eye. Along the median line of the skull it is loosely connected with its fellow by a fascial expansion, and it seems to constitute an "occipito-frontalis." I cannot trace it beyond the frontal crests, while the plane first described is easily demonstrated to extend quite to the snout.

Auricular muscles.—Three muscles of the ear may be described, besides the superficial panniculus that surrounds the conch, and is subservient to its general movements; only one of them, however, is very distinct, or has bony origin. This is a detrahens aurem; it is a stout, terete, somewhat flattened band, lying beneath, and entirely distinct from, all the foregoing layers. It arises from the lower border of the zygoma, just at the anterior margin of the glenoid fossa; proceeds directly upward and spreads a little, after reaching the conch, upon the back part of the latter. It draws the ear directly downward—what would be forward were the animal erect—and seems to represent our attrahens.

The plane of fibres that arises from the ligamentum nuchæ, sends, from its anterior margin, a large, fan-shaped, flattened fasciculus that mounts and spreads over the back part of the conch. The portion of this fasciculus that lies upon the ear itself is tolerably distinct; but in the rest of its extent the muscle is scarcely separable without violence from the general plane. It draws the conch upward and backward, uniting the offices of attollens and retrahens.

The forward motion of the ear is subserved by the transverse plane of fibres that mount the side of the head from the middle line of the throat; these having an insertion along the border of the conch.

Orbicular muscles.—The *orbicularis oculi* is small and pale, and might readily elude observation by its intimate connection with the panniculus, beneath which it lies, were it not for its definite bony attachment in front. The fibres, after encircling the eyelids, converge to a point and are inserted into the lachrymal bone, just anterior to the foramen. The *orbicularis oris* lies between the mucous membrane of the lips and the panniculus, which, as already stated, reaches to the edge of the true skin all around the mouth. Upon carefully lifting it away the orbicularis is exposed, forming a cylindrical band of fibres around the margins of the lips. These fibres cannot be fairly traced around the snout from one side of the mouth to the other, being lost, both above and below, in the thickened subcutaneous tissue.

Buccinator.—This is, in effect, a backward prolongation of the orbicularis into the cheeks, between the panniculus and the mucous membrane. There is no crossing of the fibres of the orbicularis at the corner of the mouth, nor other interlacing with the cheek muscle. The fibres of the latter form a series of semicircular loops, thrown successively further and further back from the orbicularis, till the angle of the mouth is reached. This muscle is much thickened along its periphery, by which it has definite bony attachment to nearly the whole length of the horizontal ramus and anterior border of the coronary process of the lower jaw, as well as to the greater part of the alveolar process of the upper jaw.

The two foregoing muscles close and appress the lips and cheeks. They are directly antagonized by the panniculus, the line of traction of which, and insertion into the lips, are such that they draw the lips apart, and the angle of the mouth backward, producing the characteristic expression of the opossum's face—the "risus sardonicus." This "showing of

the teeth" almost invariably takes place when the animal is irritated; but the muscles upon the face itself have but little effect in its production, compared with the action of the panniculus. I cannot find any muscles upon the lower jaw distinct from the orbicularis and buccinator, to correspond to the several described in anthropotomy; nor do I think that any such exist. There are, however, two very distinct muscles upon the side of the face, subserving the movements of the snout and anterior part of the upper lip, which I shall describe under the names of zygomaticus and levator labii superioris, without feeling at all sure that these names indicate their homology. It is worthy of note, that while these "muscles of expression" of the human subject mainly draw the mouth in different directions, in the present case they move the snout, and only secondarily affect the lips.

Zygomaticus.—This is the principal facial muscle; of large size, definite origin and insertions, and of deeper color than the rest, probably in consequence of its constant action. It lies nearly parallel with the alveolar border of the upper jaw, but still has some downward inclination as it passes forward. It arises fleshy from the root of the zygoma, in the slight depression of the malar bone just below the infraorbital ridge, filling this depression to the general level. It forms a flattened mass that may be divided almost to its origin into distinct fasciculi. These fasciculi are from three to six in number; corresponding to as many slender, terete, but strong, tendons. These tendons are as distinct as, and call to mind, those of a digital flexor. They run forward, embedded in the subcutaneous cellular tissue, as well as in the muscle about to be described, and penetrate to the skin itself. They are directly inserted into the skin of the nostrils at various places about the side of the snout. Neither the number nor the insertion of these tendons is constant; frequently only one or two reach the extremity of the muzzle, the rest being inserted into the skin of the lip just back of the nostrils. It is difficult to describe with exactness the action of this muscle; its several disconnected tendons effect the varied and delicate movements of the extremity of the snout, and of the nostrils themselves, that may be observed when the animal is sniffing about after food.

Levator labii superioris.—The action of the foregoing is aided and extended to the greater part of the upper lip, by means of the present muscle. It arises from the side of the superior maxillary, just below the preceding, a little above the alveolar border, at or near the articulation of the malar, and passes forward and downward, to be inserted into the side of the lip and muzzle. It is entirely fleshy. It draws the lip upward and backward, and the nostril directly backward. Its insertion, not precise at best, varies with individuals; and its bony origin is likewise variable.

Muscles of the Under Jaw.—The enormous bulk of the muscles that close the jaws indicates the force with which this action may be performed. These muscles fill the deep temporal fossa, from the orbit to the occiput, and from the sagittal crest to the zygoma, rendering the cranial depression convex in all directions; and also form a bulging mass both on the inside and outside of the ramus of the jaw. The latter masses are prominently displayed, without dissection, by simply opening the animal's mouth. The external pterygoid, or rotatory muscle, on the other hand, is very small and feeble, correspondently to the character of the maxillary articulation, that admits of but slight lateral movement of the jaws.

Masseter.—This muscle not only forms a bulging mass upon the jaw-bone, from the zygoma to the border of the mandible, but fills the space between the coronoid process

and the zygoma, and extends upon the cranium, beneath the temporal fascia, so far as to overlie the greater portion of the temporalis. It has extensive origin from the greater part of the temporal fascia, sometimes as high up as the parietal crest; from the stout fibrous band between the malar and supraorbital protuberance that defines the back part of the orbit, from the lower part of the occipital crest and the squamosal ridge, and from the whole of the inner surface of the zygoma. This temporal or cranial portion of the masseter is inserted into the whole of the outer surface of the broad coronoid plate. The masseteric portion proper, or that lying below the zygoma, arises not only from the lower border of the latter (being directly continuous with the above), but also, and chiefly, by a very stout tendon from the most anterior and lowest part of the malar. While the former portion is flattened and more or less fan-shaped, its fibres converging from the broad origin above described, the latter is a thick bulging mass, the general direction of the fibres of which is backward as well as downward. This prominent bundle overlaps the margin of the jaw, extends to the inner edge, and is inserted into the whole of the broad, triangular, flat space, meeting the lower border of the internal pterygoid. It reaches along the jaw, from the anterior margin of the last named muscle, to the inner hamular process of the mandible. The anterior border of the masseter is blended with the corresponding part of the temporalis.

Temporalis.—On reflecting the masseter, this muscle is seen filling the remainder of the cranial depression, separated from the foregoing (except along its anterior border) by a thick, stout aponeurosis, that forms the true tendon of the temporalis, radiating from the apex of the coronoid much as in the human subject. The periphery of the muscle corresponds to the contour of the temporal fossa; it takes origin from the occipital, parietal and frontal crests, and all the subjacent bones; it is inserted, tendinous, into the top of the coronoid, and fleshy, into the greater part of the inner surface of the same process, which is thus completely embedded in muscle. The temporal is thinner and weaker than the masseter, as well as of less superficial extent; but as already stated, the two are completely blended in some portions, and must always act consentaneously.

Pterygoideus internus.—Like the foregoing, this muscle is of great size and power, well deserving the name of "internal masseter" (Winslow), sometimes applied to it in anthropotomy. Its line of traction is such that it has little or no effect except in direct closure of the jaws. It forms on the inside of the ramus of the jaw a prominently convex bundle, corresponding in extent with, and yielding but little in size to, the masseter. It arises fleshy from the sphenoidal pterapophysis, contiguous part of palatal, and the whole of the pterygoid, which slender little bone projects downward into and is buried in the fleshy mass. Enlarging and bulging as it descends, it is inserted fleshy into the inner surface of the mandibular ramus, from the termination of the temporalis to the margin of the bone, and along the latter from the hamular process as far as the anterior margin of the masseter. It completely fills the depression between the incurved process and the articular head of the bone.

Pterygoideus externus.—The disparity in size between this and the preceding muscle is very striking; the external pterygoid being, as it were, reduced to its simplest expression. It is a very small conical, or pyramidal muscle, and is not divisible, as in the human subject, into two "heads," or parts. It arises fleshy from the alisphenoid, near the median line of the bone, close by the foramen rotundum, and proceeds, narrowing, almost directly

outward (a little backward), to be inserted by a very short tendon into the neck of the mandible, directly underneath the most internal point of the transversely elongated articular surface. Its action is necessarily very feeble and much restricted.

Muscles of the Neck.

Under this head I shall describe all the muscles of this region, not confined to the cranium, nor attached to the scapular arch, nor forming merely upward prolongations of those of the back. Without going into unnecessary subdivision of the part into "regions," we may conveniently recognize three groups of muscles: — The anterior cervical, embracing those muscles not attached to vertebræ; the anterior vertebral, including those lying upon the front of the column; and the posterior vertebral, containing those upon the back of the same. Excluded from the first group, by reason of attachment to the scapular arch, are the omo-hyoid and cleido-mastoid; from the second and third, for the same reason, the three levators of the scapula, the trapezius and the rhomboideus; and from the same two groups, as forming the third exception above taken, the cervicalis ascendens, transversalis and spinalis cervicis, etc. The great similarity of the muscles of all these groups to those of the human subject will appear from the following descriptions. The part that the paroccipital plays as a "styloid process" is worthy of note. Among the more notable features, as compared with the state of things found in man, are to be observed, the extension of the platysma myoides into a proper panniculus carnosus, as already described, discretion of sterno-mastoid and cleido-mastoid, peculiar origin of sterno-hyoid and -thyroid, relation of the latter to thyro-hyoid, expansion of digastricus, etc.

Sterno-mastoideus.—Perfectly distinct from the cleido-mastoid, though with the same origin and a parallel and contiguous course. It arises by a short, stout, flat tendon from the mastoid (sometimes from the extremity of the squamosal), and forms a stout fusiform or terete belly, that comes a little obliquely down the neck, immediately beneath the panniculus, crossing the omo-hyoid nearly at right angles, to be inserted fleshy, side by side with its fellow, into the side of the top of the manubrium, and frequently, also, the cartilage interposed between this and the clavicle, in front of, and close beside, the termination of the cleido-mastoid; its termination is in contact with the upper corner of the great pectoral.

Digastricus.—This is the first muscle seen between the jaws upon removal of the integument and panniculus. It is notable for its origin from the paroccipital instead of the mastoid, its want of a central tendon, and the expansion of its anterior belly to form a flooring to the mouth. It is bound down by the common fascia, and so is virtually attached to the hyoid; but it is not distinctly drawn to that bone by a fibrous loop. The posterior belly, stout and terete, curves around the angle of the jaw, just internal to the greater pterygoid muscle, becomes constricted and suffers partial tendinous intersection, and then spreads out into a broad, thin plane, that meets its fellow of the opposite side, and completely fills the interramal space. It is attached to the whole of the inner side of the lower jaw, from the anterior border of the pterygoid muscle to the symphysis. Besides depressing the jaw, it thus floors the mouth.

Mylo-hyoideus.—The proper floor of the mouth lies upon the digastricus — the lingual vessels running between the two. It has no distinct insertion into the hyoid, being only

connected with that bone by fasciæ. It is wholly muscular; its fibres are directly transverse; it arises from the inside of the alveolar border of the lower jaw, from the border of the pterygoid to the symphysis, and unites with its fellow along a median raphé.

Genio-hyoideus.—A large flat strip lying in apposition with its fellow along the median line, arising fleshy from the body of the hyoid, narrowing as it passes forward to be inserted by a slight tendon into the symphysis.

Genio-hyo-glossus.—This muscle, with its fellow, forms a thick, vertical, fan-shaped partition between the hyo-glossi. It arises, internal to the preceding, from the inner surface of the anterior border of the hyoid body. Its lower border, running straight to the symphysis, lies upon the foregoing. Its fibres cannot be traced more than half way to the tip of the tongue; its upper border becomes lost in the substance of the tongue (lingualis), and blends with the hyo-glossus.

Hyo-glossus.—A large muscle, forming a great part of the tongue. It arises fleshy from the lower border and most of the side of the hyoid, forming a broad, oblique plane, separated from its fellow by the foregoing muscle. Passing into the tongue its fibres can be traced along the side and under surface, even to the tip. Above and internally, it first blends with the foregoing, and is afterwards lost in the lingualis. Of the latter, it is unnecessary to say more than that it forms the fleshy substance of the tongue not included in the two foregoing muscles, and is without osseous attachments.

"Stylo"-hyoideus—A cylindrical muscle of rather large size, running obliquely forward and inward from the tip of the paroccipital to the apex of the hyoid cornu. This insertion, however, is only partial; some fibres are continuous with the constrictor of the pharynx, and seem to represent the stylo-pharyngeus of anthropotomy. Other muscles of the palate and pharynx do not fall within the scope of the present memoir.

Sterno-hyoideus.—A straight cylinder, somewhat flattened, lying along the median line, upon the sterno-thyroid, in apposition with its fellow. Instead of arising from the top of the sternum, it takes fleshy origin from the inner surface of the latter, from the body of the second sterneber, in conjunction with the (single) sterno-thyroid. It is inserted on either side of the median line, into the lower border of the hyoid. It occasionally gives off, near the middle of its course, a delicate fasciculus that is inserted into the lower outer angle of the thyroid cartilage.

Sterno-thyroideus.—This pair of muscles presents the peculiarity of arising azygos, afterwards bifurcating a little above the top of the sternum. The common muscle of origin takes rise from the body of the second sterneber, on the inner surface of the bone, bounded on either side by the sterno-hyoid, and usually blended with the latter, and terminates in a horse-shoe shaped tendinous constriction, from the sides of which its separate portions commence. These lie directly upon the trachea, covered by the preceding pair of muscles, and pass, as flattened bands of moderate width, to be inserted fleshy into the lower edge of the thyroid, on either side of the median line. A few slender fasciculi are sometimes sent up to join the hyoid bone. The fibrous constriction is sometimes wanting; then the two parts arise by simple forking of the common muscle of origin. The place of bifurcation is also variable; but I have always found it above the sternum, and have not found that the muscle ever arises double.

Thyro-hyoideus.—This is not simply a direct upward prolongation of the preceding, but perfectly distinct and moreover oblique in direction. It is a short, broad plane,

entirely fleshy, arising from the lower border of the side of the thyroid, passing inward and upward, and inserted into nearly the whole of the lower border of the hyoid.

Besides those that pass to the shoulder, the muscles of the anterior vertebral group are the three recti of the head, the longus colli and the scaleni.

Rectus capitis anticus major.—This capital prolongation of the longus colli is large and conspicuous, and tolerably distinct from the cervical portion, to which the latter name is usually restricted. It arises by attenuated slips from the transverse processes of all the cervical vertebræ; these slips lying external to those of the longus colli proper. They unite, frequently with slight tendinous constrictions, into a stout, somewhat cylindrical mass, that converges to come into apposition with its fellow over the atlas, and is inserted fleshy into the greater part of the basioccipital.

Rectus capitis anticus minor.—Smallest of the three recti, and completely hidden by the overlying major, from which, however, it is perfectly distinct. It arises fleshy from the whole anterior border of the ring of the atlas, passes directly forward over the condyle and is inserted fleshy, beside its fellow, into the basioccipital at the border of the foramen and root of the condyle.

Rectus lateralis.—A small, but perfectly distinct fasciculus, lying external to the last, separating it from the obliquus superior. It arises from the transverse process of the atlas, and runs obliquely inward and forward to the basioccipital.

Longus colli.—Occupies the front of the vertebral column from the atlas to the fourth dorsal vertebra, arising by slips from the transverse processes of all but the first cervical, and attached to the bodies of the vertebræ as it passes over them. In most of its course it is in relation to its fellow, mesial, and to the rectus major external. Above, the two muscles, or halves of the muscle, converge to meet in a point on the median line of the atlas. The large volume of muscle upon the front of the spinal column and basilar process has evident relation to such a flexion of the head and body as is necessary, for example, in attending to the pouch, or regaining foothold after suspension by the tail.

Scaleni.—I have never been able to demonstrate three; the second one—the medius—cannot be found at all, and the first (anticus) is small and blended with the third (posticus); the latter is large and conspicuous. The S. anticus, when tolerably distinct, arises from the most lateral points of the transverse processes of two or three lower cervicals, and is inserted into the first rib, near the middle of the latter, just in front of a slip from the serratus magnus. The S. posticus is perfectly distinct as to the thoracic portion. It arises from the transverse processes of all the cervicals as high up as the origin of the levator scapulæ, separating this from the rectus capitis major. Widening and flattening as it descends, it passes outward as well as downward, behind the subclavius, to be inserted by three, broad, flat, fleshy digitations into the posterior borders of the second, third and fourth ribs, near their middle, just over the corresponding digitations of the serratus, and behind the outer border of the thoracic part of the rectus abdominis. It is a direct levator costarum and flexor cervicis. Its cervical origins are sometimes blended with those of the levator anguli scapulæ for a little distance.

The muscles upon the back of the neck are the same as those found on this part of the human body. The only notable differences lie in their relative size and configuration; and even in these respects the discrepancy is not great, except in the instances of the rectus capitis posticus major, and obliquus capitis inferior, both of which are of great proportional

size. The trapezius and rhomboideus are described under head of the anterior extremity; the cervicalis ascendens, transversalis cervicis, and spinalis and semispinalis cervicis in connection with the muscles of the back, of which they are all merely the upward prolongations. The remaining muscles are :—

Splenius.—Exposed upon removal of the trapezius and rhomboideus. It forms, with its fellow of the opposite side, an isosceles triangle whose base is the crista occipitis, and perpendicular the ligamentum nuchæ. There is no lower portion corresponding to the "splenius colli," so called; the muscle terminates below in a sharp, distinct point upon a spinous process of a vertebra. It has unbroken origin from the ligamentum nuchæ, and by this from the spines of three or four upper dorsal and six lower cervical vertebræ; forms a moderately thick plane, with a thickened external border; widens as it ascends, and is inserted into the whole of the occipital crest. As the spinal origin of the muscle ends with the axis, and the median border is not always directed straight forward, nor inserted exactly on the middle line of the skull, it results that a small, triangular space between the muscle and its fellow is often, or usually left. In this space the rectus posticus major and part of the obliquus inferior appear. Otherwise, the splenius overlies and hides the greater part of the nuchal muscles.

Biventer cervicis.—On reflecting the splenius the following muscles more particularly come to view :—biventer cervicis, complexus and trachelo-mastoideus, counting from the spine outward, along the whole length of the neck, together with the two largest of the head-muscles, and the several strips of muscle coming up from the back. The biventer lies nearest the spinal column, and is ordinarily perfectly distinct from the complexus; but liable to be partly or wholly blended with the latter, in which case it forms its medial border. Its name does not express its physical character; it has no central tendinous part, but only a slight constriction, produced by irregular, fibrous laminæ, that form partial intersections. It is the longest muscle of the back of the neck; a sub-cylindrical strip, with no definite attachments along its course. It arises by slips from the transverse processes of the fifth, sixth and seventh dorsal vertebræ (but number of slips variable), lies in the same plane as the complexus, and is inserted fleshy into all that (median) part of the occipital crest not occupied by the following muscle.

Complexus.—A very large and rather thick plane of fibres separating the foregoing from the succeeding muscle; there is nothing specially "complex" in its structure. It arises by eight to ten long, slender, very distinct, fleshy fasciculi from the anterior margins of the bases of the articular processes of the six lower cervical, and two, three or four upper dorsal vertebræ. The lower fasciculi are much the longest, and rapidly diminish in length from below upward; uniting, without tendinous intersections, to form a single broad plane, curving over toward the spine, its anterior border in relation to the biventer; inserted by a short, broad, dense, glistening aponeurosis into all, or nearly all, the occipital crest. The muscle has also an attachment to the margin of the transverse process of the atlas, as it passes over the latter.

Trachelo-mastoideus.—Overlying the latter to the outer side; a muscle of considerable size. It arises by about ten long, slender, distinct, fleshy fasciculi from the articular processes of the six lower cervical and three or four upper dorsal vertebræ, close by the origins of the complexus. These fasciculi soon blend, frequently with a slight tendinous intersection, into a common plane, rather thin, and narrowing rapidly as it ascends, till it

comes almost to a point above. Its insertion, by a short, stout, flattened tendon, is ordinarily into the extremity of the occipital crest, and therefore into the squamosal; but sometimes into the mastoid just underneath this point. In most of its course it is in relation externally with the levator anguli scapulæ; internally it lies upon the complexus.

Rectus capitis posticus major.—Of large size, much surpassing the other rectus, though in turn surpassed by the obliquus inferior. It is a stout, thick, fleshy band, arising from the side of the extended curved upper margin of the spinous process of the axis, and corresponding part of the third cervical spine, extending outward as it passes forward (but not so obliquely as the obliquus inferior) to be inserted fleshy into the greater part of the depressed occipital space—all that portion of the bone between the rectus minor and complexus, from near the median line of the skull to the insertion of the obliquus superior.

Rectus capitis posticus minor.—Very much smaller; perfectly distinct; a little flattened, fleshy band, in apposition with its fellow, running straight from atlas to occiput; arising from the whole of the posterior border of the atlas-ring, from median line to base of transverse process; inserted into the occipital depression, just below the foregoing muscle.

Obliquus superior.—A small muscle, perfectly straight in its course; arising from the tip, anterior border, and most of under surface of the transverse process of the atlas, in relation in front with the rectus lateralis; inserted fleshy into the side of the base of the occiput, between the extremity of the crest and the root of the paroccipital process.

Obliquus inferior.—As was to have been anticipated, viewing the great size of the axial spine, and transverse production of the atlas, this muscle is of great extent and power. It is the only one of the four at the base of the skull that is decidedly oblique to the long axis of the neck. It arises fleshy from the whole of the expanded side of the axial spine, and is further prolonged in a point upon the side, near the tip, of the spines of the third, fourth and fifth cervicals; fills the deep longitudinal fossa along these vertebræ, passes very obliquely outward and forward, lying upon the surface of the atlas, between this and the rectus major, and is inserted into the margin, lower edge of base, and upper surface of the transverse process of the atlas. Its divarication from its fellow leaves a broad, triangular space in which the recti majores are seen. This muscle, with the great rectus, might together be almost mistaken, at first glance, for the complexus itself.

Muscles of the Thorax.

Most of the muscles lying upon the chest proceed to, or come from other parts, and are considered in other connections. This leaves only the following to be described under this head:—serratus superior and inferior; "sterno-costalis;" triangularis sterni; intercostales externi and interni; infracostales; levatores costarum; and the diaphragm.

Serratus posticus superior.—A muscle of large size, arising by a continuous aponeurotic lamina from the transverse process of the sixth (seventh?) cervical vertebra, and first two ribs; and by fleshy digitations from the third—ninth ribs; inserted into the spinous processes of corresponding vertebræ. The direction of the fibres from the spine is obliquely outward and downward. In its upper portion, fleshy fibres almost reach the spine; below, the aponeurosis of attachment grows broader. The last fleshy fasciculus is very short, and interdigitates with one from the obliquus abdominis, about two inches from the spine.

Serratus posticus inferior.—The direct downward continuation of the plane of the fore-

going, but effectually a distinct muscle, by a difference in the direction of its fibres. On account of the wider intercostal spaces below, the fleshy digitations are much broader than those of the S. superior. They are four in number, arising from the tenth—thirteenth rib, interdigitating with the obliquus abdominis. Although they decrease in length from above downward, the lower one reaches nearest to the spine, in consequence of overbalancing decrease in the breadth of the aponeurotic attachment. The fibres of this muscle are directly transverse; and, while the S. superior lifts the ribs, this draws them directly away from the median line, and so continues expansion of the chest below.

"*Sterno-costalis.*"—There is a small muscle upon the outside of the thorax, regarding the name and homology of which I am in doubt. It arises by a thin aponeurosis of varying width, from the second, and sometimes part of the third, sternebcr, this aponeurosis lying between the pectoralis major and rectus abdominis, and closely investing the latter. It proceeds obliquely forward and outward; at the external border of the rectus it becomes fleshy, and proceeds to be inserted fleshy into the first rib, opposite the insertion of the scalenus anticus. In general characters it recalls the pectoralis minor, and may possibly be regarded as that muscle, arrested on its way to the coracoid, since the three pectorales elsewhere described are really only dismemberments of one — the pectoralis major.

Triangularis sterni.—This muscle is of considerable superficial extent, but very thin, and usually divided into halves along the median line, by an interval corresponding to the width of the sternebers. Each half arises as a continuous plane along the outer border of the four lower sternebers (not from the xiphoid), and proceeds obliquely outward and forward, lying upon the whole of the costal cartilages of the second—sixth ribs.

Intercostales.—The *externi* terminate on the "true" ribs at some distance from the sternum (in general, along the outer border of the rectus abdominis); but on the floating ribs they reach to the margin of this bone. The upper ones are most oblique and shortest; the lower ones are nearly vertical. The *interni* cover the whole of the inside of the thorax from spine to sternum. The direction of their fibres decussates with that of the preceding muscles in the usual way.

Infracostales.—At the back of the thorax, near the spine, the internal intercostales run over two or three contiguous ribs instead of being confined to a single costal interspace. The plane of these elongated overlapping intercostals is directly continuous; the inner surface is blended with the successive true intercostals. The width of the series is least above; toward the bottom of the thorax it increases; and similarly the individual infracostals elongate, widen, and become more distinct.

Levatores costarum.—A well marked series of little oblique muscles, running from the apex of a transverse process to the succeeding rib. They arise fleshy, and are inserted partly tendinous into the rib between the tuberosity and the angle. The lower ones are longest, as well as largest and most distinct; some of them have two heads, taking origin (by the outer head) from the rib above, as well as from the transverse process. Their collective force in elevating the ribs would be considerable.

Diaphragm.—With little modification the description of the human diaphragm would apply to that of the opossum. The central tendon commonly resembles the trefoil in shape, but varies with individuals from the trefoil through cordiform to broad reniform. It is equidistant from the circumference of the thorax, but the middle leaflet approaches the xiphoid, and each lateral leaflet the two last ribs. The muscular fibres radiate in all directions from

the central tendon; the plane going to the xiphoid in the thinnest, and sometimes almost divided along the median line by a membranous interval. The lateral fibres terminate about an inch from the margin of the thorax, by separated flattened fasciculi, one for each floating rib, interdigitating with those of the transversalis abdominis. The digitations sometimes only fairly blend just before reaching the central tendon; but there is great individual difference in this respect, as well as regarding the general thickness and fleshiness of the muscle. The two crura are of unequal lengths; the right, besides being longest, is also stoutest. It ends on the body of the third lumbar; the left usually between the second and third; both are directly continuous below with the anterior vertebral ligament. The anterior margins of the crura are tendinous; behind, muscular fibres descend to the insertion of each crus, and are attached to the vertebra just above. The anterior tendinous border of each crus curves over about an inch above its final insertion, to become continuous with its fellow of the opposite side, overarching and enclosing the aortic opening, the margin of which is thus, as usual, entirely fibrous. The muscular fibres of the two crura decussate just above the aortic opening, at a slight angle, and then divaricate to surround the œsophageal aperture. The latter is a fissure, bounded on both sides and below by muscle; above, it just reaches the border of the central tendon. Its left margin, representing fibres that come from the right crus, is thicker than the other, and forms a well marked ridge or fold. The foramen for the vena cava is situated above and to the right of the œsophageal, in the central tendon, at the junction of the central and dextral leaflets. It is circular, and the smallest of the three principal openings; the fibres that form its periphery are thickened and strengthened; the most noticeable of these increased fibres is a set that proceeds from the margin of the opening obliquely to the œsophageal fissure. The "ligamentum arcuatum" passes from the posterior margin of each crus to the transverse process of the first lumbar, and base of the last rib, overarching the spine transversely. It is more or less directly continuous with the fascia of the transversalis abdominis. The psoas parvus and lumbar muscles pass up a little way behind it. I do not notice any "internal arcuate ligament" well distinguished from the rest of this border of the muscle.

Muscles of the Back.

Of the numerous muscles of the back, those constituting the first three "layers," as usually described in anthropotomy, and part of those constituting the fourth and fifth layers, are described in other connections, *to wit:* the trapezius, latissimus, rhomboideus and levator anguli scapulæ, with the muscles of the anterior extremity; the two serrati postici with the muscles of the thorax; the splenius, biventer, complexus, trachelo-mastoideus, recti capitis superior and inferior, with the muscles of the posterior vertebral region of the neck. The general disposition of the muscles that remain to be noticed is much the same as in man; the chief differences are found in the lumbar and sacral region, and relate to the development of large caudal muscles. The following description may suffice to exhibit the characters of the remaining muscles of the fourth and fifth layers, without going into tedious and unnecessary detail.

In the loins, that is, from the apex of the ilium to the last rib, there is on either side a large sub-cylindrical mass of muscle, divisible into five parallel, longitudinal bundles.

The innermost, or most lateral of these, seems to represent a series of "intertransversales," lying between and upon the large "transverse processes," separating the psoas from the quadratus lumborum. It takes origin from the ilium, below and inside the apex, and proceeds upward to the eleventh — twelfth rib, thus entering the thorax, past the diaphragm, and there lying upon the anterior surfaces of the bodies of the vertebræ.

The next three bundles occupy the broad, shallow fossa between the transverse and articular processes. The largest and most lateral of these is the quadratus lumborum, beginning at the apex of the ilium, and proceeding to the last rib. It is wholly muscular, and incompletely divisible into several layers of fasciculi; and blends above with the sacro-lumbalis. The latter, and the longissimus dorsi—both to be presently noticed in more detail—together form the third bundle, and constitute the "erector spinæ." The fourth bundle is the very distinct, terete belly of origin of a caudal extensor, described below.

The fifth bundle occupies the narrow deep fossa between the articular and spinous processes, representing a "multifidus spinæ." Below, it runs uninterruptedly into the tail. It consists of a series of little oblique fascicles, filling the groove, arising fleshy from articular processes, and inserted tendinous into spinous processes, two or three vertebræ above. At the last dorsal its bed becomes very narrow and the muscle is proportionally diminished in size. It again enlarges, however, and continues upward, with much the same characters, but intimately blended with the spinales dorsi and colli.

The erector spinæ in the lumbar region consists mainly of a series of flattened tendons that take origin from the apices of the spinous processes, and blend into a strong fibrous layer that invests the subjacent muscle, and is continued as a strong fascia down over the sacrum. Laterally, and toward the thorax, however, the sacro-lumbalis part becomes a stout fleshy mass that blends with the quadratus, and is then continued upon and inserted into the last two or three ribs, at a little distance from the spine.

The upward prolongation of the sacro-lumbalis—the "musculus accessorius"—is perfectly distinct from the longissimus. It is a flat, narrow, sub-prismatic strip lying along the outer border of the latter, just behind the origins of the serrati, an inch or more from the spine. It consists of a series of slips arising fleshy from the ribs, and inserted tendinous into the second or third rib above. The several tendons are tolerably distinct, but the muscular parts are completely blended.

This muscle, properly speaking, ends at the first rib. To its outer side, and partially blended with it, a slip arises from the third—first rib, and is inserted into the transverse process of the seventh cervical. This is the "cervicalis ascendens."

The erector spinæ, after disengaging the sacro-lumbalis, continues upward upon the spine, overlying the multifidus, and more immediately the spinalis, as the longissimus dorsi. The latter is distinct from the sacro-lumbalis, but inextricably blended with the spinalis. The longissimus and spinalis together fill the groove between the ribs and the apices of the spinous processes; the former nearest the median line, the latter more external. Together they consist of a series of long, stout, flattened tendons, arising from the apices of the spinous processes, and continually giving off numerous fleshy slips that are inserted into the articular and transverse processes of the vertebræ, and angles of the ribs. The two muscles, hitherto confused, separate opposite the fourth or fifth dorsal—the origin of the biventer cervicis intervening. The longissimus passes outside the biventer, complexus and trachelo-mastoideus, separating the latter from the cervicalis ascendens, and continues up

the neck as the "transversalis cervicis." This forms in the neck, and along the upper part of the thorax, a tolerably distinct flattened muscle, divided into slips that continue below as longissimus, and are inserted above into the transverse processes of the third—seventh cervical vertebræ, by as many separate tendons. It separates the lower part of the trachelomastoid from the upper part of the levator anguli scapulæ. The spinalis, likewise running up the neck, passes inside the biventer and complexus, and terminates in a series of stout, fleshy slips lying upon the sides of the spinous processes of the vertebræ, and inserted near their apices, as high up as the third cervical—where the greater rectus and obliquus capitis begin.

Muscles of the Tail.

The muscles of this part, as usual in prehensile-tailed animals, are large and numerous, and especially notable for the extent of their attachments to the pelvis, and sacral and lumbar portions of the spine. They form an elongated cone, diminishing rapidly just behind the pelvis, and thence tapering regularly and very gradually to the tip of the tail. For a little distance beyond the root of the tail, all the muscles are perfectly distinct, and most of them are directly continuous; in the rest of their course, those that extend the entire length of the tail become more or less blended, diminish in size both by the actual decrease of the volume of muscle and by the giving out of fasciculi to be inserted by tendons at various points, and lose continuity in a measure by being firmly attached to the salient points at the extremity of each vertebra, so that, in effect, they are a succession of short muscles. Certain tendons, however, run the entire length of the tail without intermediate insertion; these are described below.

The structure and disposition of the flexing set of muscles is the same as that of the extending; but in bulk, and consequently in power, it greatly preponderates over the latter. This confers the grasping power of the tail; while the extent of pelvic and vertebral attachments of both sets of muscles is sufficient to support the weight of the hanging body without inconvenience. Although the volume of muscle toward the tip of the tail is inconsiderable, the animal can suspend itself from a suitable object, as a twig, by only wrapping around it an inch or two of its tail. The large muscles of the base of the tail are in this case really brought into play by the action of their long tendons. Action of the flexor muscles is favored and increased by the series of V-shaped bones that serve as so many *points d'appui;* and after the spinous, transverse and articular processes cease, the quadrangular extremities of the vertebræ replace these processes as points of muscular attachment and action.

Besides the caudal muscles proper, others take origin from the coccygeal vertebræ. These are:—the posterior part of the glutæus maximus, the "femoro-coccygeus" (when this exists as distinct from the latter), the cruro-coccygeus, the pyriformis (if the disputed vertebra be really caudal), and the levator recti. These are all considered in other connections.

On stripping off the thick, squamous, reticulated skin, the tail is seen to be encased in an uninterrupted sheath of very dense fascia, comparable for thickness and strength with the ordinary fasciæ of the body, much as the *fascia lata* of the human subject compares with similar structures in other parts of the body. This fibrous sheath gives off septa from its under surface that penetrate between, and separate, the different bundles of muscle,

and is attached to the salient points of all the vertebræ. The series of septa that it forms between the V-shaped bones, separating the two principal flexing bundles, is the strongest. The long tendons above referred to lie embedded in this fibrous sheath, and are thus plaited, as it were, into stout, flattened bands. These bands are four in number, two above, and two below, on each side of the median line; the tendons of each are from twelve to twenty in number, and may be distinctly seen without dissecting, lying close beside each other, most of them running the whole length of the tail, but some ending by attachment to nearer vertebræ. In general effect, these bands of tendons call to mind the conjoined tendon of a digital flexor, before the filaments become separate from the common bundle. Each tendon arises from a muscular fasciculus in the sacral or pelvic region, as will be presently noticed. Besides encasing the tail, the fibrous sheath gives origin, by its under surface, to muscular fasciculi, particularly along the course of the tendon-bands, which cannot be raised from the subjacent muscle without laceration of the latter.

On either side of the median line, on the superior aspect of the tail, a rather small multifid muscle occupies the groove between the spinous and articular processes. This is the backward continuation, unbroken, of the series of slips that fills the same groove in the lumbar region, and it has precisely the same characters. Fasciculi constantly arise from successive vertebræ, and blend externally and superiorly into a continuous band. These slips are, or rather this muscle is, distinct, as far as the sixth—eighth caudal; there it virtually ends, partly by insertion by separate tendons into the proximal extremities of the vertebræ, but chiefly by attachment to the under surface of the tendon band. The few fleshy fibres that may be traced nearly to the tip of the tail, on the under surface of this band, between its successive attachments to the vertebræ, may properly be regarded as the continuation of this muscle.

The chief extensor muscle of the tail lies next to the preceding, on the outer side of it, as far as its muscular part extends; above it, along its tendinous portion. This is the muscle that forms the bundle of long tendons. It arises high up in the lumbar region, where it forms a distinct belly lying in the groove between the articular and transverse processes, covered by the aponeurotic origin of the erector spinæ, and behind, or to the median side of, the quadratus lumborum. In the sacral and upper caudal region it completely fills the groove—at first between the articular processes and the ilium, subsequently between the same processes and the transverse. It consists of a large number of fasciculi, taking fleshy origin from successive vertebræ at the very bottom of the fossa, and each ending in a long, slender tendon. The course and arrangement of these tendons has already been noticed. The fasciculi that form the tendons may all be easily dissected apart to their very bases, and form in effect so many small muscles. Most of them become tendinous at nearly the same point—opposite, or a little beyond, the tuberosity of the ischia. Two or three of the most posterior of them, however, continue fleshy for a greater distance.

To the outer side of the foregoing lies another smaller muscle, properly belonging to the extensor series, but really subservient to the lateral movements of the tail. It represents the continuation, behind the ilium, of the most lateral or ventral series of the lumbar muscles. It arises fleshy from the transverse processes of the sacrum, and corresponding aspect of the ilium, and forms a small, continuous bundle, situated upon the very apices of the successive transverse processes as long as the latter continue to be developed.

Well developed interspinals and intertransversals connect these processes as long as the latter continue of normal size and shape. The first named muscles disappear first.

The foregoing muscles all proceed over the back of the pelvis to the tail, above the median lateral line of the latter. The remaining muscles constitute the flexor series; these are best displayed by cutting open the symphysis pubis, and wrenching the sides of the pelvis apart. Three arise from the innominate bone; another (not here described owing to an accident that destroyed my notes) arises from the face of the sacrum.

Ischio-coccygeus.—The most lateral of the flexor series. It arises fleshy from the edge of the ascending ramus of the ischium, just below its junction with the ilium, and spreads out to form a broad, fan-shaped muscle, that is inserted by separate fasciculi with the transverse processes of the five or six upper caudals—beginning with the one next to that from which the pyriformis arises. Its anterior border is in relation with the posterior border of the latter muscle. Its action chiefly subserves the lateral movements of the tail, besides serving as another attachment of this member of the body.

Pubo-coccygeus.—This is the most anterior fasciculus of the general plane of muscle that arises from the inner surface of the *os innominatum*. It takes distinct fleshy origin, from the horizontal ramus of the pubes, opposite the articulation of the marsupial bone; and proceeds as a flat slip inward and backward, along the border of the ilio-coccygeus. It has partial insertion, by aponeurosis, into the apex of the second V-shaped bone, but is chiefly directly continuous with the following muscle:—

Ilio-coccygeus.—Arises fleshy from the iliac bone not far from its middle, and represents the posterior lateral part of the intra-pelvic muscles that pass to the tail. Narrowing somewhat from its original dimensions, it passes out of the pelvis alongside the preceding, with which it is partially blended, and continues on the under surface of the tail, close to the median line. These muscles, and the sacral ones, are of considerable size, and form the bands of flexor tendons already noticed.

Muscles of the Abdomen.

The abdominal parietes are formed of five muscles, as in man, besides the *quadratus lumborum*, which was noticed in another connection. The pyramidalis, rudimentary or absent in the human species, is here highly developed, as in the Monotremes proper; the external oblique, and rectus both have extensive thoracic prolongation.

Obliquus externus.—This muscle is of great superficial extent. It arises by ten or eleven thick fleshy fasciculi, from as many lower ribs, interdigitating with each of the three serrati, but not with the latissimus dorsi. The external border of the latter overlies the whole origin of the obliquus. The fleshy digitations begin at the middle of the second—third rib, and upon successive ribs approach nearer the spine; the last one arises at the junction of the costal cartilage with its rib. From this point, the posterior margin of the muscle descends straight to the tip of the ilium, and is bound down by a layer of common intermuscular cellular tissue, hardly to be called an aponeurosis of the obliquus internus (outer layer of lumbar fascia). From the tip of the ilium to the base of the marsupial bone the lower border forms a well defined, stout "Poupart's ligament," continuous below with the general fascia of the thigh; beneath it, near its middle, the femoral vessels emerge

with the anterior crural nerves to the outside. The insertion of Poupart's ligament is rigidly defined; it is into the inner aspect of the extreme point of the outer prong of the base of the marsupial bone, just opposite the origin of the pectineus. This narrow, distinct, glistening tendon forms the outer "pillar of the ring." The "ring" is of large size, and pyriform or elliptic contour, its broadest part uppermost. About an inch from the insertion of the tendon, the fibres curve away from its border, overarching the ring, and descending again on the inner side nearly or quite to the base of the marsupial bone, forming the "mesial pillar." The contour of the ring is well marked; an "intercolumnar fascia" closes the opening; the spermatic cord enters at its lower corner. After forming the mesial pillar, the aponeurosis is firmly attached to the whole length of the marsupial bone, as it passes over the outer surface of the latter to proceed to its final insertion into the linea alba and symphysis pubis. The muscle is thick and fleshy as far as the outer border of the rectus, where it becomes aponeurotic, and closely invests the rectus, as far down as the beginning of the pyramidalis, after which it lies directly upon the latter. In the inguinal region it becomes aponeurotic along an imaginary line drawn from the top of the ilium to the top of the marsupial bone. All but the most superior and anterior of its fibres pass almost directly downward.

Obliquus internus.—This muscle is much smaller than the preceding, as well as thinner; its superficies equals that of the abdomen alone. It arises fleshy from the greater part of Poupart's ligament, and from the apex of the ilium, and, by an aponeurosis common to it and the transversalis, from the lumbar fascia. The lower border is fleshy, and stretches nearly horizontally inward from Poupart's ligament to the upper part of the marsupial bone, a stout bundle of fibres being inserted into the tip of that bone. The rest of the muscle passes more and more directly upward, till its posterior part is vertical. Its anterior margin ends along a "linea semilunaris" by blending its aponeurosis with that of the transversalis. This termination of the fleshy fibres is along a straight, oblique line from the tip of the marsupial bone to the most dependent point of the tenth rib. From this line inward no separate aponeuroses for internal oblique and transversalis can be demonstrated; and the same is the case with the lumbar aponeurosis back of a line from the tip of the ilium to the last rib, though it is presumable that two fibrous layers enter into the composition of these aponeuroses. The costal insertion of the muscle is by three or four fleshy digitations into as many of the lower ribs.

Transversalis.—Except for a small space, as noted below, this muscle is fleshy throughout. It arises fasciculate from the inner surfaces and costal interspaces of all the floating ribs, interdigitating with the diaphragm; the lumbar aponeurosis of origin is formed by coalescence of two layers enclosing the quadratus; upon which, and upon blending with the border of the internal oblique, the muscle becomes fleshy. It is attached fleshy to the top of the ilium; its lower fleshy border is not directly continuous with the cremaster, so that the latter does not appear, as in some animals, as a direct scrotal prolongation of the transversalis; but is separated from the latter, more or less perfectly, by an areolar interval, and may usually be traced to the ilium itself. The transversalis, thickest above, is everywhere transverse in the direction of its fibres, the uppermost of which overlie the xiphoid cartilage; and along the upper two-thirds or three-fourths of its length fleshy fibres reach the linea alba. There is no splitting of the aponeurosis to get outside the rectus below; near the point where the muscle passes outside the rectus in the human subject,

fleshy fibres cease, and thence downward the muscle is inserted into the linea alba by an aponeurosis as broad as the rectus is wide, completing, with its fellow of the opposite side, an oval space. This fascial layer represents the conjoined aponeuroses of transversalis and internal oblique; it lies wholly inside the rectus.

Rectus. ("*Rectus internus.*")—The straight muscle is noteworthy for its extensive thoracic prolongation, absence of "lineæ transversæ," and situation wholly outside the two preceding. It is a continuous broad flat strip, running the whole length of the trunk from apex of thorax to symphysis pubis. It arises fleshy, about half an inch broad, from the sternal portion of the first rib, and lies along either side of the median line of the body, at first directly upon the ribs and sternum, where it is separated from its fellow by the origin of the pectoralis; and afterward upon the transversalis and internal oblique aponeurosis. Its thoracic portion is immediately covered, at first by the little "sterno-costalis" (see supra) and then by the pectoralis; but the greater part of this portion is directly overlaid by the external oblique. In the upper half of its abdominal extent, it is also covered by the same, and intimately adherent thereto; as well as, mediately, by the third division of the pectoralis. From the termination of the latter to the symphysis, the pyramidalis intervenes between the rectus and the external oblique. The rectus is inserted fleshy into the lower part of the marsupial bone, and the symphysis pubis. Its great size, continuity of contractile tissue, and especially its thoracic prolongation, render it an unusually powerful flexor of the body, in obvious relation to the several indications that have already been pointed out, as requiring fulfilment in the opossum's economy.

Pyramidalis. ("*Rectus externus.*")—Of much the same proportions as in the true Monotremes: similarly developed in both sexes. It is a large triangular plane, wholly muscular, lying between the body of the rectus and the aponeurosis of the external oblique. It arises from the symphysis and whole length of the marsupial bone; the fibres proceeding diagonally upward and inward to be inserted into the linea alba, as high as the origin of the lowest pectoral. This muscle, acting with its fellow, approximates the marsupial bones, and appresses them to the abdomen, which action is furthered by the rectus, and opposed by the three lateral muscles of the abdomen, and also by the pectineus.[1]

Cremaster (of the male).—The spermatic cord, coming from the abdominal scrotum, passes over the base of the marsupial bone, enters the ring at the lower part, and at once divides in three parts. The vas deferens, abruptly changing its course, winds around the bone just named and passes inward to the base of the bladder, soon joined by the ureter. The artery and vein take a middle course together, running, generally upon a bed of fat, only about half way up to the renal vessels, to empty into the aorta and cava (not renal) vein, on either side. The cremaster, only slightly changing its course, runs outward, parallel with the lower border of the transversalis, and is apparently given off from the latter; but it is, however, usually traceable in its integrity to the top of the ilium, where it really takes origin. I doubt that the change in the direction of the cremaster, by passing over the foot of the marsupial bone, is sufficient to decidedly augment the traction of the

[1] The human pyramidalis, small, variable and rudimentary or wanting, has been supposed to be present for the purpose of facilitating "the expulsion of the last few drops of urine." (See respectable text books of human anatomy.) Writers who hazard so absurd a conjecture would do well to look up their comparative anatomy, and learn that morphology may require presence of parts for its own sake.

muscle upon the testicle. There is scarcely more deviation from a right line than would be produced by the passage of the muscle over the brim of the pelvis alone.

Cremaster (of the female: Ilio-marsupialis).—The same muscle in the female, instead of forming a "round ligament of the uterus," goes to the pouch, and has essentially the same relations to the mammary glands that the male muscle bears to the testicle. "The compressor muscle [of the marsupial mammæ in general] arises from the ilium between or near to the lower attachment of the internal oblique and transversalis abdominis; it passes out of the abdominal ring, bends round the marsupial bone, expands as it turns upward and inward behind the pouch to surround partly by carneous, partly by sclerous fibres, the mammary glands, dividing into as many insertions as there are glands of its own side. This muscle ('ilio-marsupialis' of Cuvier) is the homotype of the cremaster of the male; and the chief function of the ossification of the internal pillar of the abdominal ring (marsupial bone) is to add the power of the pulley to the compressor of the mammary gland, and effect the requisite change in the course of the contractile fibres." (Owen, Comp. Anat. III, p. 769.) The change in direction is much greater in this case than in the instance of the male cremaster, and undoubtedly may have the effect ascribed. The strong powers of suction that the infant opposum has been shown to have, however, might be supposed to render such office unnecessary, or at least of only secondary importance to the function of protruding the nipples from the folds of the integument in which they are invaginated before coming into use; but both these actions may be fairly attributable in some measure to this muscle.

Muscles of the pouch.—The formation of the pouch is essentially the same as that of the scrotum; the two are evidently homologous parts. Each consists of a duplication or bagging of loose integument of the abdomen; in the one case, a loosely pendulous closed sac is formed by eversion and protrusion of a tegumentary fold from within; in the other, a more closely appressed open pouch results from inversion and invagination of a duplication of skin from without; in both, the receptacle so formed lodges the most important sexual glands. Contraction of the scrotum and its contents is effected by the cremaster and the dartos; corresponding actions upon the pouch and mammary glands by the ilio-marsupialis, as has just been seen; but further contractibility than dartoid tissue could afford being evidently required, special muscles make their appearance. The question of the homology of these muscles with the contractile scrotal tissue is one on which I am not prepared to speak; nor can I give so full an account of the muscles themselves as would be desirable. My opportunities were very unfavorable, all my female subjects having been virgin, with the pouch consequently not fully developed. In my dissections I only succeeded in demonstrating transverse and lengthwise planes of muscular fibre between the layers of integument, without being able to define them with precision. According to Owen's brief description, (the only one accessible to me at the time of writing), the marsupium "is composed of a duplicature of integument, of which the external fold is supported by longitudinal fasciculi of the panniculus carnosus, converging below to be implanted in the symphysis pubis. The mouth of the sac is closed by a strong cutaneous sphincter muscle." (Op. cit., p. 770.) This "sphincter" is undoubtedly the transverse fibres I saw, the longitudinal ones just mentioned being those of the general cutaneous muscle.

Muscles of the Perinæum.

Although these muscles, properly speaking, belong rather to special organs than to the general frame-work of the body, and consequently, like the pharyngeal, laryngeal, and some others, scarcely fall within the scope of the present memoir, I give them brief notice, on account of their intrinsic interest. The muscles of the organs of generation, as might be expected, offer some unusual conditions, as compared with those of ordinary mammals, though they are not peculiar to the animal in its own order.

Sphincter ani.—The external sphincter, which surrounds and includes the uro-genital as well as the anal orifice proper, is rather small and thin, and very intimately adherent to the integument around the common opening. It is circular in general outline, but after embracing the anus extends forward, with a fascial attachment towards the symphysis, over the dorsum of the penis, when the latter lies occluded by retraction. It is presumed to aid or continue the erection of the organ, when the latter is protruded, by compressing the dorsal veins.

Sphincter cloacæ.—Within or above the preceding lies the proper sphincter of the rectum, which appears to represent the "internal sphincter" of anthropotomy, and to be formed mainly or wholly by an aggregation of the circular fibres of the rectum; it has no direct action upon the genital apparatus.

Levator ani.—The muscular floor of the pelvis is well developed. It forms a rather thin, subcircular plane, corresponding, in a general way, to the contour of the pelvic outlet; and embraces the genitalia as well as the rectum. Posteriorly, where the muscle is thickest, the margin is free, or at least without direct fascial attachment to the caudal vertebræ; and the fibres run uninterruptedly from one side to the other. These circular fibres curve forward on either side, and converge over the penis; the anterior and lateral margins of the muscle have extensive, though diffuse, fascial attachment to the ischia and pubes—to the latter more particularly. Large masses of fat usually rest upon the levator, forming protuberances on either side of the rectum.

Levator recti. (*Recto-coccygeus*).—This little muscle appears to compensate for want of decided attachment of the levator ani to the coccygeal vertebræ behind: it may really belong to that muscle, but my dissections showed it as distinct. It is a delicate fasciculus, of considerable length, that arises from the chevron bone of the second or third coccygeal vertebra, or both, and proceeds forward and downward above the plane of the levator ani, to the rectum itself, upon which it spreads. It makes direct traction upon the gut, and must exert considerable force when the tail is fixed, notwithstanding its delicate proportions.

Levator penis.—This peculiar muscle, the most exceptional of the set acting upon the organ, as it appears to be characteristic of those marsupials that have a forked glans, and is not found throughout the order, occurs in a highly developed and curious condition. It is the most superficial and lateral of the penal muscles, and is immediately exposed upon removal of the levator ani, above the plane of which it lies, upon the crura, and afterwards, in its tendinous portion, upon the dorsum, of the penis. The muscular part consists of opposite halves, each of which takes extreme origin from the ramus of the ischium, and is also attached to the surface of a crus, as it passes over the latter, and forms a spindle-shaped belly, that mounts the dorsum of the penis, just behind the border of the symphysis

pubis, and, there becoming tendinous, joins the tendon of its fellow on the median line. After such union of the two muscular parts at nearly right angles with each other, the single delicate terete tendon so formed runs along the whole length of the dorsum of the penis, lying in the median line, to the bifurcation of the glans. There the tendon also forks or splits in two, and each half runs along the superior margin of the urethral groove of the glans, nearly to the apex of the latter. The important action of this singular muscle, although complicated, is evident. In the first place it has an effect very similar to that of the erector itself, in steadying and straightening, if not actually compressing, the crura. Next, when the penis is protruded backward, and stiff, the muscle causes the organ to point forward, by drawing upon it, until its apex swings around in the arc of a circle whose centre is at the end of the crura. Finally, the terminal splitting of the tendon enables the muscle to draw the forks of the glans apart, so as to insure the entrance of each into its own vagina; while the attachment of the tendons to the margin of the urethral groove dilates the latter, and facilitates the seminal discharge. The muscle is thus a director as well as a levator of the penis; and it is certainly very perfectly adapted to the purpose.

Erector penis. — Each crus is enveloped by a muscular tunic, very similar to those enfolding the capsules of the Cowperian glands. The erectors have no terminal fixed point of origin from the ischiatic ramus. The bony attachment of the muscle is by a fascia from the pubes, near the posterior margin of the symphysis, and distal extremity of the crus; the muscle is bulbous, or pear-shaped, as it were, being doubled upon itself by returning to near its point of origin after thickening and spreading over the crus, and firmly grasping the latter. It terminates by a stout, laminar tendon, upon the cavernous portion of the penis, close by the bulb. Its action is simple, direct compression of the crus, in much the same way as, *e. g.*, the uterus contracts upon its contents.

Retractor penis. — There is a pair of muscles for the special purpose of withdrawing the penis into the pelvis upon the subsidence of the priapism. These muscles are remarkably long and slender; being, when extended, some six or eight inches in length, with a width of only about an eighth of an inch, and a thickness of scarcely one-sixteenth. These attenuated slips arise muscular side by side from the anterior surface of the centrum of the last lumbar, or first sacral, vertebra, and passing along through the pelvis, diverge so as to pass one on each side of the rectum, to which they are imperfectly adherent by condensed cellular tissue. Leaving the rectum, and gaining the root of the penis by direct passage across the slight interval between these two points, they run along the sides of the body of the latter organ, and are finally attached muscular at the outside of the base of the glans, and somewhat upon the under surface, nearly opposite the point of bifurcation. Besides their proper office, these muscles have probably some action as reins or stays in guiding or steadying the penis whilst it is erect.

Accelerator urinæ.—As the corpus spongiosum, like the corpora cavernosa, has two crura, or begins as lateral halves, giving rise to separate urethral bulbs, this muscle likewise consists of two portions, which, however, meet and coalesce on the median line, beneath the roots of the penis, across which they run in a directly transverse course. The muscle, though small, is distinct; the two parts, each embracing and compressing a bulb, join across the urethra without a tendinous interval.

The thick and tumid prostatic part of the urethra, and also the thin anterior membranous

tract, are both surrounded by well marked muscular fibre. The pairs of Cowper's glands are likewise invested, and very strongly, by separate, dense, bulbous muscles, serving for their compression.

Muscles of the Anterior Extremity.

It may be most natural, at any rate I find it most convenient, to consider under this head the muscles by which the anterior extremity is connected with the rest of the body, as well as those that lie wholly upon the member itself. Any division of the body into muscular "regions" is purely artificial; few muscles, comparatively speaking, lying and acting wholly within the limits so mapped out.

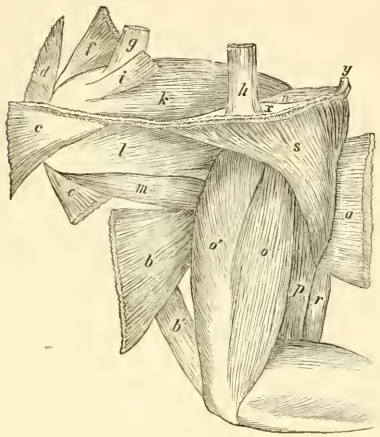


Fig. 28.— Muscles of right shoulder, about three-fourths natural size. (*x*, acromion; *y*, end of clavicle).

The anterior extremity is attached to the body by the sterno-clavicular articulation and fifteen muscles, distributed as follows: —To the clavicle two, cleido-mastoid and subclavius; to the scapula seven, trapezius, rhomboideus, serratus magnus, levator anguli scapulæ, omo-hyoideus, atlanto-acromialis,[1] and atlanto-scapularis;[1] to the humerus five, pectoralis major, in three divisions, latissimus dorsi, and dermo-brachialis; to the ulna one, epitrochlearis, a slip from the latissimus dorsi. These will be described in the order in which they are enumerated above.

Cleido-mastoideus. — Distinct in its whole length from the sterno-mastoid, but with a common origin; more terete and much smaller. It runs nearly straight downward from the mastoid to be inserted fleshy at the middle of the clavicle. Its course is oblique to that of the sterno-mastoid; its situation is superficial; it is in relation, externally, with the anterior border of the slip from the trapezoid.

Subclavius. — Of considerable size, and perfectly distinct from contiguous fascial or muscular structures; arises fleshy from the first rib near the sternal extremity, opposite the outer margin of the thoracic prolongation of the rectus abdominis, and proceeds obliquely outward to be inserted fleshy, into the distal extremity, of the clavicle, tip of acromion, and cleido-acromial ligament. Some of its fibres occasionally blend with those upon the under surface of the cleido-acromial muscle that lies upon the articulation.

Trapezius. — (Figure 28, *c*.) This muscle is extremely thin, but of great superficial area, forming a triangular plane that extends from the occiput to the last dorsal vertebra,

[1] These names may be alike unnecessary and unwarrantable; but, as explained further on, I have no alternative but to impose them, not knowing what, if any, names these two muscles may have already received. The muscle I call "atlanto-acromialis" may be the same as that described under the name "trachelo-acromialis," in, *e.g.*, the horse, where it is said by Owen to arise from the transverse process of the atlas and four successive vertebræ, and to spread over the acromial portion of the scapula, and descend as far as the middle of the humerus; but its disposition, in the opossum, is not strictly correspondent. The other, "atlanto-scapularis," may be morphologically the same muscle; but it is perfectly distinct in the opossum.

and curves around the shoulder to the middle of the clavicle, thus determining the contour of the side of the neck, as in man. It arises fleshy, or by a very short aponeurosis in some places, from the whole of the occipital crest, ligamentum nuchæ and spines and interspinous ligaments of all the cervical and dorsal vertebræ, overlying the rhomboideus and greater part of the latissimus. The upper fibres pass downward, outward and forward; the middle ones directly forward; the lower ones obliquely upward and forward; converging, in this manner, into a broad, flat tendon, that passes along and is attached to the scapular spine, acromion, and distal half of the clavicle. The aponeurosis plays freely over the root of the scapular spine; elsewhere it is intimately adherent to the fascial investment of the two spinati muscles, the deltoid and great pectoral. The muscular fibres themselves are not, however, continued directly into the pectoralis major, as is said to be the case with some marsupials (*e. g., Perameles lagotis:* teste Owen, C. Anat. III., p. 11). The portion of the muscle that is inserted into the clavicle often, perhaps usually, forms a separate fasciculus that lies along the anterior cervical border, and is only united to the rest of the muscle near the side of the occiput. The part that lies over the protuberance of the shoulder is always extremely thin, and discontinuity of the plane at this point produces this clavicular slip.

Rhomboideus.—(Fig. 28, *d.*) There is no distinction of rhomboideus major and minor; the single muscle forms a continuous thin plane, overlaid by the trapezius, arising from the occipital crest and nuchal ligament next to the origin of the trapezius, and from the vertebral spines and interspaces as far down as the commencement of the latissimus, which is at a point just opposite the middle of the trapezius and the extremity of the scapula. It is inserted into the posterior border of the latter, fleshy, or with a very short aponeurosis, for nearly an inch. It draws the shoulder blade backward and upward.

Serratus magnus (fig. 28, *e*), and *Levator anguli scapulæ* (fig. 28, *f*).—The very large triangular plane of fibres that converges to be inserted into the posterior border of the scapula cannot be separated into two muscles except by arbitrary use of the knife. The upper fibres elevate, and the lower depress, the extremity of the bone; the whole acting together draw the shoulder directly forward upon the thorax. This arrangement, in all probability, relates to the animal's hugging of objects when climbing. The cervical or vertebral portion of the muscle, which is the levator, arises in slips from the posterior part of the transverse process of the four or five lower cervical vertebræ, more or less blended with the posterior scalenus. The thoracic or costal portion, which is the serratus, arises from the first eight or nine ribs, by as many fleshy digitations; beginning at the middle of the first rib, curving gradually towards the back-bone on successive ribs from above downward. The four or five lower slips are most distinct from each other, and interdigitate with the obliquus abdominis externus; they pass obliquely upward and backward; the upper ones directly backward; the latter are overlaid by the scalenus as low down as the fourth rib.

Omo-hyoideus.—(Fig. 28, *i.*) A broad, flat ribbon-muscle, arising fleshy from the side of the hyoid bone between the genio- and thyro-hyoid, and running downward a little way upon the sterno-thyroid; then curving away from the trachea, passing obliquely across the neck, underneath the sterno- and cleido-mastoid, above and beyond the shoulder to gain the *posterior* superior angle of the scapula, where it is inserted by a short, flat tendon, beside the insertion of the atlanto-scapularis. The extension of this muscle to the further end of the scapula at once augments its power, and causes it to become virtually a third elevator of the scapular angle. The omo-hyoid is a single simple band, with one curve in its whole

length; it is not bound down and made to change its course by an aponeurotic loop; nor is it divided into two bellies by a central rounded tendon. But just where it passes the sterno-mastoid an imperfect, flat, tendinous intersection may frequently be found.

Besides the levator anguli scapulæ proper and the omo-hyoid, which acts as such, there are two other muscles, that proceed from the atlas to the scapula,—one to each extremity of the latter—and draw the bone directly upward. Not knowing what names they may have received, I shall describe them under the following ones: —

"*Atlanto-acromialis.*"—(Fig. 28, *h.*) A stout, flattish ribbon, arising by a slight tendon from the side of the ring and root of the transverse process of the atlas, passing downward (gradually widening as it descends), and a little obliquely outward, to be inserted fleshy into the root of the acromion and for half an inch along the under lip of the scapular spine. It lies superficial in the greater part of its extent, being only covered by the trapezius after passing the sterno- and cleido-mastoid. It pulls the scapula upward and somewhat forward.

"*Atlanto-scapularis.*"—(Fig. 28, *g.*) Similar in general characters to the foregoing; slenderer, more terete, longer, and with a more oblique line of traction. Its action upon the scapula is almost identical with that of the omo-hyoid. It arises from the apex and posterior border of the transverse process of the atlas, and is inserted into the plane surface at the posterior superior angle of the scapula; generally between the edge of this bone and the insertion of the omo-hyoid; but the relative insertions of the two vary somewhat. Teleologically, this muscle is a perfect "levator anguli scapulæ"; but it is not the muscle so named in anthropotomy; the latter existing, as we have seen, as the vertebral portion of the great plane of the serratus.

Pectoralis major.—(Fig. 28, *a.*) The first part of the pectoral is of only moderate bulk, although it arises from the whole length of the sternum, from tip of manubrium to xiphoid. It takes origin from the median line of the surface of the bone, and consequently in apposition with its fellow. Its upper corner overlies the insertion of the sterno-mastoid; but it has little, if any, origin from the clavicle. It is thinnest at its central part, where it overlies the second pectoralis,—the latter seeming, as it were, to be developed at the expense of this part of the major. It has an extensive insertion—into the whole length of the outer edge of the bicipital groove, as low down as the apex of the deltoid. The lower free border is much longer than the upper, and is folded smoothly under in an unusual manner; just as the collar of a coat is folded over, without any twisting of the fibres. This inflected portion is entirely separated from the rest of the muscle, except, of course along the line where it is turned under. It is the tendon of this inflected portion that is chiefly connected with the tendon of the dermo-brachialis elsewhere described. The upper portion of the muscle is much twisted. Those fibres that lie superficial at the manubrium do not proceed along the clavicular border of the muscle to the top of the bicipital groove, but are directed downward, so that their insertion is near the apex of the deltoid; while those that lie upon the deep surface opposite the second and third ribs, are directed upward, soon emerging to the surface, and are inserted into the upper part of the bicipital groove. The muscle has the usual action and lines of traction.

Pectoralis major, its second division.—The second or middle pectoral is the smallest of the three. It arises for about an inch and a half along the middle of the sternum, wholly covered by the first division. The fibres converge to produce a fan-shaped muscle that

is inserted into the greater tuberosity of the humerus, and upper part of the outer lip of the bicipital groove. It abducts and anteducts the humerus, at the same time rotating the bone inward.

Pectoralis major, its third division.—Of large size, and the longest of the three, though thin and flat. It arises, in apposition with its fellow, from the linea alba for an inch or two below the xiphoid, narrowing rather suddenly to become a thin, slender ribbon that proceeds in a straight line obliquely forward and outward to be inserted, by a narrow, thin aponeurotic tendon, into the upper part of the outer edge of the bicipital groove close to the humeral tuberosity. Its insertion and action are nearly the same as those of the middle pectoral; it continues and augments the force of the latter. With its fellow, it forms a large V across the ventral aspect of the body, lying chiefly upon the thoracic prolongation of the rectus, and the scalenus, both of which it crosses obliquely. Its presence is of a part with the general preponderance of muscles that aid the flexion of the body and limbs over those that extend; it probably relates to the manipulation of the abdominal pouch and genitalia, in much the same way that has gained for the latissimus dorsi, in anthropotomy, the pseudonym of "scalptor ani."[1]

Latissimus dorsi.—(Fig. 28, *b*.) The great muscle of the back extends from the termination of the rhomboideus to the 3d and 4th lumbar vertebra. The aponeurosis of origin is narrowest above, where fleshy fibres reach nearly to the median line, and broadest over the loins; this tendinous lamina and the fleshy part of the muscle are both very thin. The upper border of the muscle is directly transverse; at first in relation with the rhomboideus, afterward with the teres. The lower or exterior border is very long; it proceeds obliquely forward and outward, presenting the usual twist by means of which it becomes the upper border of the tendon of insertion. The latter is an inch or more long, but scarcely a fourth of an inch wide; it is implanted in the humerus about an inch below the head of the bone, on the posterior or inner border of the bicipital groove, alongside, or a little above, the insertion of the teres.

Dermo-brachialis. (*Panniculus carnosus.*)—The large cutaneous body-muscle envelopes nearly all the back, side, and belly, with very extensive origin from the skin of the parts, meeting its fellow along the middle line of the belly, but separated, in most of its extent, over the back. It is properly a part of the panniculus of the head and neck already

[1] The pectoral muscle of another (a non-clavicuiate) marsupial, the *Perameles lagotis*, is thus described by Owen. (Comp. Anat. and Phys. III. p. 12):

"The pectoralis major is, as usual in the marsupial and many higher quadrupeds, a complicated muscle; it consists of an anterior or superficial and a posterior or deeper portion; the anterior portion receives the strip before mentioned from the trapezius, there being no clavicle or clavicular ossicle interposed in the Perameles; its fibres converge, increasing in thickness as they diminish in breadth, and are inserted into the anterior and outer part of the strongly developed pectoral ridge. The second and main portion of the pectoralis arises from the whole extent of the sternum; its fibres are twisted obliquely across each other as they converge to be inserted into the inner part of the pectoral ridge; some of the internal and posterior fibres of this portion of the twisted pectoral pass obliquely upward and behind the anterior fasciculi, and are inserted into the coracoid process, thus representing the pectoralis minor. Beneath this latter portion of the pectoral, a long and slender muscle passes to be inserted into the anterior part of the tuberosity of the humerus; this may likewise be regarded as a dismemberment of the pectoralis major, but it arises from the fascia of the rectus abdominis, below the cartilages of the lower ribs."

The three pectorals of marsupials recall the three of birds, and the suggestion is strengthened by the avian affinities that these animals and the Monotremes show. One might well be excused for taking the hint, at first blush of the question; but nevertheless it seems fallacious, the balance of evidence being decidedly the other way. If the three pectorals are really dismemberments of one, it is more than probable that what I have called "sterno-costalis" is really the true pectoralis minor.

described; but the latter is more or less distinct. Fibres converge from their radiation over the skin at large, to form a fan-shaped muscle, no longer adherent to the skin; the upper and lower borders of the muscle, after its separation from the skin, are in general relation, respectively, with the posterior borders of the latissimus and great pectoral. The muscle has definite insertion into the humerus along the outer border of the bicipital groove, by a very thin, wide aponeurotic tendon, more or less blended, in different instances, with the tendons of insertion of the pectorals. It retroducts the humerus, and appresses it to the side of the body; otherwise it is an adjuvant of the trunk muscles in curling up the body, when it takes fixed point of action from the humerus.

Omo-anconeus (*Dorso-épitrochlien* Duv.). — (Fig. 28, *b'*.) Two or three inches from the humerus the latissimus dorsi gives off from its under surface, near its lower border, a stout, flat, muscular slip, half an inch broad. This passes nearly at a right angle from the latissimus, along the inner surface of the scapular head of the triceps, past the elbow, to be inserted, by a definite tendon, into the ulnar olecranon, near the inner humeral condyle; and by a thin aponeurotic expansion blends with the general fascia of the forearm. Though of comparatively small size, this muscle, from its very advantageous line of traction, is a powerful adjuvant of the latissimus in retroducting the arm, and of the triceps in extending the forearm. The design appears to be increase of power of curling the body, as, *e. g.*, around limbs of trees, etc. Although here appearing as actually only an offset from the latissimus, it presents itself as really the homotype of the sartorius of the pelvic extremity. It is the same as that described by Duvernoy in the Gorilla as "dorso-épitrochlien." There is no attachment of this muscle by aponeurosis, or otherwise, to the scapula or thorax.

The articulated parts of the scapular arch are joined together by a small muscle devoted exclusively to this purpose, in addition to the usual joining by the indirect action of the trapezius and deltoid. From the scapula five muscles act upon the humerus, and three upon the forearm; from the clavicle none proceed to the arm except part of the deltoid. The muscles about the shoulder itself have much the same situation, shape and action as in man; but there is no teres minor. The coraco-brachialis is extremely small. There is one (tricipital) extensor cubiti, and three flexors, the biceps being divided and inserted in an interesting manner.

Cleido-acromialis. — (Fig. 28, *n.*) A small muscle, distinct from the supraspinatus, and almost, if not wholly, from the subclavius. It arises, by an aponeurotic tendon that becomes fused with the fascia over the supraspinatus, from the acromion and proximal half of the scapular spine; runs transversely across the top of the shoulder, and along the corresponding half of the clavicle, strengthening and protecting the loose, weak acromio-clavicular articulation. Sometimes its under surface is somewhat blended with the termination of the subclavius; but it cannot be regarded as an extension of that muscle. I do not know what name it may have already received.

Subscapularis. — The want of convexity of the scapula causes this muscle to be thin and flat. It arises from the periphery and greater part of the thoracic surface of the bone, and is broadly inserted into the lesser tuberosity of the humerus, rotating the latter inward, and thus directly antagonizing the infraspinatus. Its short, thick tendon passes across the shoulder-joint, between the latter and the coraco-brachialis; an aponeurosis radiates upon the thoracic aspect of the muscle, much as in man; many fleshy fibres take origin from this fascial investment.

Supraspinatus. — (Fig. 28, *k*.) The muscular portion fills the whole fossa to the level of the spine, and bulges above the upper border of the bone. Much of the insertion into the top of the greater tuberosity is fleshy; the short, thick, tendinous part is in intimate relation to the joint. The muscle has the usual action.

Infraspinatus. — (Fig. 28, *l*.) Larger than the preceding, in consequence of the position of the scapular spine, but with the same general characters. The insertion into the lower part of the great tuberosity is almost entirely fleshy, and more or less blended with that of the foregoing. The muscle everts the humerus, directly counteracting the subscapularis. No teres minor can be demonstrated as distinct from the rest of the fleshy mass filling the infra-spinal fossa.

Teres major. — (Fig. 28, *m*.) Arises fleshy from the posterior inferior angle of the scapula, and proceeds along the lower border of the bone, in relation with the upper border of the latissimus dorsi. It is a stout, subcylindrical muscle, passing inside the scapular head of the triceps, to be inserted by a short, thin ribbon-tendon into the inner or posterior edge of the bicipital groove, a little below and behind (sometimes opposite) the insertion of the latissimus, with the tendon of which, however, its tendon is not conjoined. It draws the humerus directly backward, and to a less degree rotates it inward.

Deltoid. — (Fig. 28, *s*.) Large in superficial extent, but of only moderate thickness. It is thinnest along its origin and where it passes over the tuberosity of the humerus; thicker along either border. It arises from nearly the whole of the scapular spine, acromion, acromio-clavicular ligament, and outer part of the clavicle, as far as the insertion of the cleido-mastoideus, fleshy from the clavicle, but by a very short aponeurosis, more or less blended with the fasciæ over the trapezius and infraspinatus, along the rest of its extent. From this wide origin fibres converge to a point, to be inserted fleshy into the prominent, roughened tubercle on the anterior face of the humerus, midway between the extremities of this bone. It has the usual actions and lines of traction; its texture is rather coarser than that of surrounding muscles. It covers the shoulder-joint and upper part of the humerus, and overlies, in intimate relation with, the upper part of the great pectoral on the one side, and the origins of the brachialis anticus and outer humeral and scapular heads of the triceps on the other. The tendons of the pectorals separate it from the biceps.

Coraco-brachialis. — This muscle, though very small, is not by any means rudimentary. It is about an inch long, tendon and all, and rather stout for its length. It arises by a slender tendon from the tip of the coracoid, forms a spindle-shaped belly, lying directly on the head of the humerus, from which it is separated by the tendon of the subscapularis, passing across the latter, alongside the coracoid head of the biceps, to be inserted fleshy into the humerus just at the origin of the inner humeral head of the triceps, of which it appears almost like a direct upward prolongation. Its action must be very feeble.

Biceps. — (Fig. 28, *r*.) This muscle is remarkable in several respects. It is "biped," rather than bicipital; the division of the two portions almost makes two distinct muscles; one goes to the radius, as usual, the other to the ulna. As a whole, the muscle arises from the upper margin of the glenoid fossa, the tip of the coracoid, and the intervening notch. While this tendon of origin is not completely separable into two parts without some laceration of sclerous fibre, it really consists of two differently shaped portions. But neither of these parts enters the capsular ligament of the shoulder-joint; so that it is a question whether the true glenoid or "long head of the biceps" really exists; the part that is found,

though thus incompletely divisible into two portions, may be in fact only the coracoid, or "short head," which reaches to the margin of the glenoid across the intervening notch, only in consequence of the small size and sessile condition of the coracoid. That part that goes to the glenoid is thick and terete; the rest is thin and flat. An inch or so below the origin the two parts separate; these two fleshy bellies do not afterward reunite. The muscle from the flattened coracoid tendon is the larger of the two, and presents externally the appearance of a stout fusiform belly; but internally it is scooped or fluted, as it were, forming a longitudinal depression in which lies the slenderer, more terete, or spindle-shaped belly that comes from the glenoid tendon. The large coracoid muscle suddenly diminishes in calibre as it dips down between the pronator radii teres and the extensor bundles on the forearm, and passes to the usual insertion, by a stout rounded tendon, into the tuber radii. The smaller glenoid part accompanies the other into the cleft between the muscles on the forearm; but it is inserted into the base of the coronoid process of the ulna. I have no idea what useful purpose is subserved by this construction of the chief brachial flexor, but it may convey a hint as to its morphological relations.[1]

Brachialis anticus.—(Fig. 28, *p*.) The "short" flexor of the forearm does not lie entirely upon the front of the humerus, nor bifurcate above to enclose the apex of the deltoid. It arises from the outer surface of the bone, especially along the slight elevation that marks the upward prolongation of the external condylar ridge, passing obliquely around the insertion of the deltoid to gain the front. Fibres take origin from the middle third of the humerus, part of the upper third, and nearly all the broad intercondylar surface. The muscle dips down between the bundles upon the forearm, alongside the tendon of the biceps, to be inserted with the latter into the coronoid process of the ulna.

Triceps.—(Fig. 28, *o*, outer humeral, and *o'*, scapular, head.) The single cubital extensor is of great size, and has extensive attachments. It is only incompletely divisible into three heads; the scapular head alone is perfectly distinct from the others, but representing the middle division of the muscle it serves to partially separate the two humeral portions. This long head arises from the inferior border of the scapula for half an inch or more beyond the glenoid fossa; its fibres at first pass straight downwards, but afterward more obliquely, converging to the common great tendinous intersections. The other two heads, blended together, conjointly take origin from nearly the whole of the posterior aspect of the bone between the brachialis anticus and teres above, and condylar ridges below. There are tendinous laminæ in the muscular substance, which separate the scapular from the humeral heads; but the chief one is that running some distance up the posterior surface of the muscle, as in man. The inner humeral head is the shortest; it is inserted, together with the scapular, into the olecranon itself; the outer head is longer as well as

[1] This arrangement of the biceps, which I have verified by repeated dissections, differs much from that given by Owen (Comp. Anat., iii, p. 12) as occurring in another marsupial—the *Perameles*. This author says: "The *biceps* is a powerful muscle, although its short head from the coracoid process is suppressed. The long head has the usual origin and relation to the shoulder joint; its tendon is very thick and short. The fleshy belly joins that of the strong brachialis internus [qu. anticus?] situated at the external side of the humerus, whence it takes its principal origin from the short deltoid ridge, closely connected there with the second portion of the triceps, and deriving some fleshy fibres from the lower and outer third of the humerus. The portion of the biceps arising by the long head soon resolves itself into two distinct penniform muscles; the tendon of the outer one joins that of the brachialis, and this conjoined tendon simply bends the forearm, while the inner tendon bends and pronates; the latter, which is a direct, though partial, continuation of the biceps, is inserted into the ordinary tubercle of the radius; whereas the outer tendon is attached to the fore part of the proximal end of the ulna."

larger, and is inserted, moreover, into the outside of the shaft of the ulna for nearly an inch below the olecranon. Some fibres of the conjoined triceps tendon are continuous with the slip from the latissimus dorsi, and the fascia of the forearm.

The forearm is very like our own in contour; pronation and supination are perfect; and almost all the muscles of anthropotomy are present, with much the same relative size, shape, position and action; certain of them, however, differ a little in their insertion. No marsupial, perhaps, has a more perfect "hand" than the opossum. The fingers are very mobile, and the thumb perfectly opposable. The most notable muscular absentees are the extensor secundi internodii pollicis, and the flexor longus pollicis.

In the supine forearm three muscular regions, containing as many sets of muscles, may be conveniently, if artificially, distinguished. First, the *radial*, containing the long and short supinators, and long and short radial wrist extensors; second, the *anterior brachial*, containing the round and square pronators, sublime and profound digital flexors, and long palmar; third, the *posterior brachial*, containing the ulnar wrist extensor, common digital extensor, extensor of little finger, extensor of index and first pollical internode, and extensor of pollical metacarpal. Notwithstanding the number and variety of the extensors, the flexor system, as usual, greatly preponderates in power.

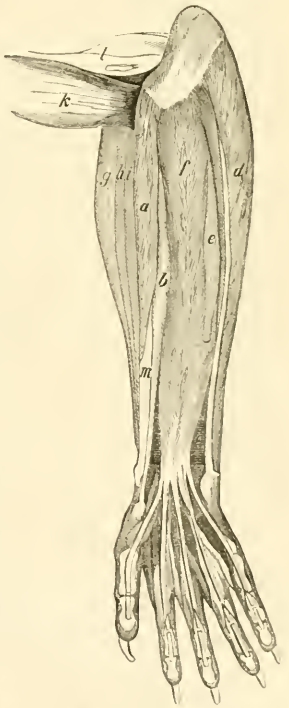


Fig. 29.—Muscles of the right forearm, anterior surface; natural size.

Supinator longus. — (Fig. 29, *g*, and fig. 30, *a*.) Largest of the four muscles of the region, arising highest up on the condylar ridge, and mainly determining the contour of the parts. A somewhat flattened spindle with thick fleshy origin, narrowing midway or at the lower third, to a rounded tendon that passes over the head of the radius to be inserted into the corresponding side of the wrist.

Supinator brevis.—There is no large muscle curving over the upper third of the radius from the humeral condyle and ridge of the ulna, as in man. The homologue of the short supinator is found in a small, slender fasciculus, about an inch long, that arises from the outer condyle, or rather from the contiguous part of the joint-ligament, in intimate relation with the head of the radius, and lies upon, and is attached to, that bone, as far down as the insertion of the pronator radii teres. It has a fascial investment, and is perfectly distinct from the superincumbent muscles.

Extensor carpi radialis "longior."—(Fig. 29, *h*, and fig. 30, *b*.) Arises from the external condylar ridge next below, and partly overlapping the S. longus, lying in its whole length between this and the muscle next described. It bears the same general characters as the long supinator; its tendon passes, in company with the tendon of the

latter, along a groove over the head of the radius, and is inserted into the base of the index metacarpal.

Extensor carpi radialis brevior.—(Fig. 29, *i*, and fig. 30, *c*.) As long as the preceding and rather larger, with a stouter, flatter tendon. It arises lower down on the condylar ridge, and from the condyle itself; it lies alongside the preceding; its tendon occupies the same groove in the radius; it is inserted into the base of the middle metacarpal.

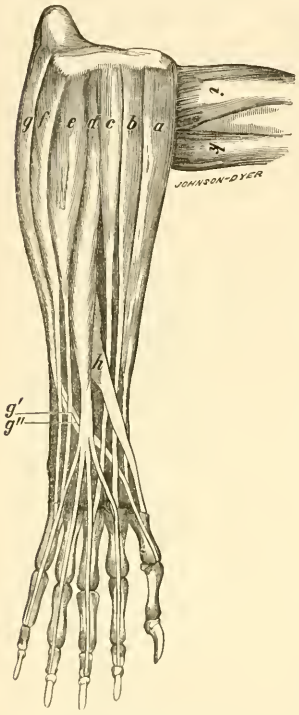


Fig. 30.—Muscles of the right forearm, posterior aspect; natural size.

Pronator radii teres.—(Fig. 29, *a*.) A large, flattened muscle arising fleshy from the internal condylar ridge as high up as the foramen; with no ulnar origin; crossing obliquely past the brachial flexors to gain the radial side, to be inserted by a broad aponeurosis into the middle third of the radius. The usual action.

Pronator quadratus.—(Fig. 29, *c*.) Well developed, with the usual shape, situation and action. It is restricted to the lower part of the arm, instead of extending it to the elbow, as in some marsupials.

Flexor carpi radialis.—(Fig. 29, *b*.) A somewhat flattened spindle, arising from the inner condyle next below the round pronator, which it separates from the digital flexors; its origin is blended with that of the latter. Its slender, round tendon, nearly or quite as long as the fleshy part, runs over the head of the radius, to be inserted into the base of the index metacarpal.

Flexor carpi ulnaris.—(Fig. 29, *d*.) A bi-pinnatifid muscle, larger than either of the foregoing, and, like the long supinator, mainly determining the contour of the part. The posterior vane is larger than the other, and continues fleshy almost or quite to the insertion; the anterior one is only two-thirds as long, so that the stout tendon occupies part of the anterior border of the muscle. The muscle arises from the internal condyle, the corresponding face of the olecranon, the upper half or two-thirds of the edge of the ulna, and the intermuscular septum between itself and the digital flexors. Its tendon passes over the head of the ulna to be inserted into the most prominent bone of the carpus on the ulnar side (pisiform), besides giving off fibres that are continuous with the annular ligament and the general fascia of the parts. The ulnar nerve runs along the inner surface of the muscle.

Palmaris longus.—(Fig. 29, *e*.) This is a slender fusiform muscle lying between the last described and the digital flexors, with both of which it appears intimately blended, but may be traced as a distinct fasciculus to the condyle. Its long, slender, round tendon passes a little obliquely outward over the digital flexors, gains the middle of the front of the wrist and there spreads out into the palmar fascia, being specially attached, on the radial side, to the cartilaginous spur that lies appressed upon the ball of the thumb, and correspondingly on the ulnar side, to the pisiform bone. This attachment on the ulnar

side, did not, in any of the specimens examined, show transverse muscular fibres corresponding to the "palmaris brevis" of anthropotomy. The concavity of the wrist is thus arched over by a fibrous band attached to the most prominent point on the radial and ulnar side. The tendons of both digital flexors pass underneath this bridge; being further bound down, however, by a proper annular ligament.

Flexor digitorum communis sublimis s. perforatus and *Flexor digitorum communis profundus s. perforans.*— (Fig. 29, *f.*) In the hand the tendons of the two sets of digital flexors are perfectly distinct, and have precisely the characters of the human perforans and perforatus. But in the arm the muscular parts are so much blended that they cannot be separated without rather forcing the dissection; their connection with the radial and ulna wrist flexors, on either side, is also intimate. The fleshy portions are therefore most conveniently to be considered together. The large mass of muscle occupies the whole of the front of the forearm between the two wrist flexors, with very extensive origin from both bony and fibrous surroundings. Of the part that chiefly represents the deep flexor, an inner portion arises from the olecranon and upper two-thirds of the back of the ulna; an outer (the most distinct one) from the extremity of the inner condyle of the humerus; and a middle, from the upper half of the back of the radius, interosseous membrane and contiguous surface of the ulna. The part that represents the superficial flexor arises from the lowest and back part by the condyle and the contiguous part of the joint ligament.

Imbedded in this fleshy mass lies a slender little spindle of muscle, quite distinct from the rest. It may be traced entire to its origin from the very edge of the ulnar articulating surface of the humerus. Its delicate tendon is lost in the common bundle of the conjoined deep flexor tendons; at least I did not succeed, after several dissections, in tracing it to a digit. It seems to be the flexor longus proprius pollicis, arrested on its way to the thumb. It will be shown below that the tendon of the proper long flexor of the great toe is similarly attached to the common flexor of the toes.

The tendons of the profound digital flexor are five in number — the thumb being supplied like the other digits. They are not separated until the muscle has passed the wrist, being indissolubly bound together into one stout, flattened band, and enjoying no individual motion. This dense fibrous band cannot be split into five tendons without arbitrary use of the knife. It fills the concavity of the front of the wrist, where it is bound down by a very distinct annular ligament, different from the simple bridge formed by the palmaris longus, and so long as to be properly called a sheath. After separating on the palm, the tendons pass to the fingers as stout, flattened bands, and proceed to be inserted into the base of the ungual phalanges. In the palm, they are bound down by the palmar fascia; as they pass along the second phalangeal internode each is bound down by a small but very distinct, stout, transverse fibrous band.

The accessory muscles (*lumbricales*) of the deep flexor tendons are well developed. They are four in number, the thumb having none. They arise from the radial side of the tendons at the point of separation of the latter from each other; and sometimes further up on the conjoined tendon. They have some fascial connection with the superficial flexor tendons. The four little fasciculi are perfectly distinct from each other; they are inserted on the radial sides of the bases of the four fingers, or rather into the fibrous sheath that envelopes the fingers.

The sublime flexor tendons are four in number, the thumb not being supplied; extremely

slender and delicate, like silken threads, somewhat liable to be overlooked or destroyed, unless carefully sought for. In passing the wrist they are confined by the annular ligament, but are not included in the single large tendinous bundle just described. Contrary to what is the case with the deep flexor tendons, these superficial ones may be easily separated from each other as high up as the muscular part, or even further. After reaching the fingers each one splits, as in man, to embrace a deep flexor tendon; the forked extremity is inserted into either side of the base of the second digital phalanx. The tendons are also slightly bound down where they pass the bases of the fingers.

Extensor digitorum communis.—(Fig. 30, *d.*) Proceeding down the external condyle, we find the origins of three muscles appertaining to the posterior brachial region, besides the three of the radial region already described. They are superficial, and pass straight down the forearm; the other muscles upon the back of the forearm are deep seated and oblique in direction. The common digital extensor is the first of this superficial set, arising from the external condyle next below the extensor carpi radialis brevior, and lying between this muscle and the proper extensor of the little finger. It is incompletely divisible into two parts; one for the index and middle, the other for the ring and little fingers; but all four tendons can be separated high up on the arm. The four separate from each other upon the back of the wrist, and each one proceeds to be inserted into the back of the base of the ungual phalanx of a finger. As they pass the bases of the fingers all are bound down by, or rather spread on either side to help form, the fascia of the parts.

Extensor minimi digiti.—(Fig. 30, *e.*) Perfectly distinct from the foregoing, with which it agrees in shape, but is rather smaller. It arises next below on the external condyle, from the extreme anterior point of the latter. Its extremely delicate tendon runs alongside that of the preceding to the same insertion, and is sometimes virtually, if not actually, blended with it. Before reaching the finger it frequently gives off a filamentous slip that joins the extensor tendon of the annularis.

Extensor carpi ulnaris.—(Fig. 30, *f.*) Scarcely larger than either of the preceding; lying superficial along the edge of the ulna, arising from the lowest point of the external condyle and contiguous part of the joint, and for a short distance from the ulna itself, becoming tendinous midway, running along a slight groove in the head of the ulna to be inserted into the base of the fifth metacarpal.

Extensor indicis (*et pollicis*).—(Fig. 30, *g.*) Proper extensors of the first and of the second pollical internodes do not exist; but the extensor of the fore finger has two perfectly distinct tendons, one of which goes to the thumb and supplies the place of the extensor secundi internodii pollicis. The muscle lies deep seated on the shaft of the ulna, covered by the ulna carpal extensor, and is small and inconspicuous. It has no condylar origin, arising from the upper half or third of the ulnar crest. Its two long, delicate tendons gain the radial side by passing diagonally across the lower third of the forearm, underneath the digital extensor tendons. One (ib. *g″*) runs along the back of the forefinger to the base of the ungual phalanx, side by side with the index tendon of the common extensor, and virtually, if not actually, blended with the latter. The other (ib. *g′*) passes still more obliquely to gain the thumb along the back of which it runs, to be inserted into the base of the distal phalanx. This thread-like tendon is the only extensor of the pollical internodes.

Extensor ossis metacarpi pollicis.—(Fig. 30, *h.*) This muscle is of great size, as if to

compensate for the want of other thumb extensors. It is the most deep seated of all the extensors, but its tendon speedily becomes the most superficial of any, overlying the tendons of the supinator longus and the two radial wrist extensors in its oblique passage across them to gain, and be inserted into, the base of the first metacarpal. The muscular part is pinnatifid, two or three times as long as the tendinous, lying flat upon the radius and ulna, and taking extensive origin from both these bones, as well as from the interosseous septum. On one side fleshy fibres extend nearly to the wrist; on the other the tendon runs higher up. The tendon is very stout and flat, and gives off fascial expansions on either side.

————? There is one other muscle upon the forearm that may or may not be considered as the representative of the anconeus. It is a short, stout little bundle of fibres that passes transversely across the inner aspect of the convexity of the elbow, from the inner condyle to the olecranon, filling up the notch or gap that would otherwise be apparent between these two salient points. I make it out to be perfectly distinct from any of the muscular surroundings. Its action must be feeble and very limited.

The remarkable muscular similarity of the opossum's arm to that of man, as indicated by the muscles just described, is carried out to a surprising extent by the little muscles proper to the hands. The palm is very fleshy; there is a well developed "ball" upon the thumb, and a corresponding massa carnea along the ulnar border, in both of which substantially the same muscles that are found in man may be demonstrated. In addition to these, and to the lumbricals already noticed, there are two sets of interossei—palmar and anconal. The fingers are freely movable in all directions, and the palm may be hollowed from side to side, as well as closed in the ordinary way.

Adductor pollicis. Adductor minimi digiti.—On stripping off the flexor tendons and lumbricals, we come upon a broad, thin plane of transverse muscular fibres, resting upon the palmar interossei, and covering the whole palm. This has a median raphé, along the whole length of the third metacarpal, from which and from the carpal bone that the latter articulates with, the muscle takes origin. Passing across the hand, on either side from the median line, the fibres converge to be inserted into, respectively, the inner side of the the phalanx of the thumb and of the little finger, forming the two muscles whose names head this paragraph. They contract the palm from side to side.

Abductor pollicis. Flexor brevis pollicis.—A large flattened mass, forming the chief bulk of the ball of the thumb, arising from the trapezium, annular ligament, base of metacarpal, and inner surface of the appressed cartilaginous spur, and inserted into the base of the first phalanx of the thumb, beside the preceding. A few fasciculi may be demonstrated as partially distinct, though with much the same origin and insertion. These represent the short flexor.

Opponens pollicis.—A small fusiform muscle, perfectly distinct from the preceding, lying upon the extreme radial border of the hand, in intimate relation with the tendon of the flexor ossis metacarpi pollicis, along the first metacarpal; inserted into the outside of the base of the first pollical phalanx.

Abductor minimi digiti.—Similar to the corresponding muscle of the thumb; arising from the pisiform bone, lying along the ulnar side of the fifth metacarpal, and inserted into the outside of the base of the first phalanx of the little finger. A true flexor brevis is scarcely or not demonstrable as distinct.

Opponens minimi digiti.—Occupying the extreme ulnar margin of the hand, this small muscle proceeds to the same insertion with the foregoing. It arises from the pisiform bone and annular ligament.

In the arrangement of these muscles of the lateral digits it is to be noticed, that the thumb and little finger are each adducted and flexed by a broad plane of fibres proceeding from the median line of the hand; that each is abducted and extended by a more external bulging mass of fibres. The flexores breves may be lost in the inner part of these last named fibres; and the opponentes be more or less blended with the outer part of the same.

Interossei.—The palmar are of large size, lie upon the metacarpals rather than between them, and are much blended together, forming a fleshy mass that completely fills the concavity of the palm. They seem rather to flex the fingers than to produce lateral movements; but when the fingers are fully extended, they may aid in spreading them apart. There are four dorsal interossei perfectly distinct from each other, lying between the bones. Each is pinnatiform, arises from contiguous sides of two metacarpals, and is inserted into the radial side of the base of a finger.

[Note. In the long interval between the preparation and publication of this Memoir, we have adopted for the muscles that act upon the carpus and metacarpus the necessary change in nomenclature proposed by Wilder (*these Memoirs*, I, 1865, p. 32), by which the so-called "flexors" become *extensors*, and the so-called "extensors" become *flexors*. As the change cannot now be readily made, the muscles are here presented under their usual names, with this explanation of an apparent discrepancy between our determinations in the present instance, and those published for Man (*N. Y. Medical Record*, July, 1810) and for the Ornithorhynchus (*Proc. Essex Inst.*, VI, 1871, p. 152), (— see, however, the concluding Part of this Memoir).]

Muscles of the Posterior Extremity.

The pelvic arch, unlike the scapular, being immovably connected with the body, is primarily acted upon by but few muscles; and those that pass from the body to the femur are not many. Those that, though really attached in some way or another to the pelvis, act not upon, but from it, are all considered in other connections, with the exception of the psoas parvus, which is most conveniently described here: they are the perineal and abdominal muscles, part of the vertebral series, and two special caudal muscles, the ilio- and ischio-coccygeus. Two other caudal muscles, acting upon segments of the pelvic appendage, most properly come under the present head.

In consequence of extreme elongation and narrowness of the haunch bones, their over- and under-lying muscles have rather unusual configuration. The six small muscles collectively known in anthropotomy as "rotatores femoris," are all present and well developed. There is a small muscle upon the hip joint not found in man. There is no tensor vaginæ femoris; no crureus or subcrureus can be demonstrated.

Psoas parvus.—(Fig. 31, c.) This muscle is well developed, being nearly as large as, and much longer than, the psoas magnus. It arises fleshy from the bodies of all the lumbar vertebræ, except the uppermost one, forms a stout conical belly, contracting opposite the top of the ilium into a slender, flat tendon that is inserted into the horizontal ramus of the pubes, nearly in front of the acetabulum, at a point just above and outside the articulation of the marsupial bone. The tendon is dense and shining; above, it spreads on the ventral surface of the muscle; below, its edges and insertion are defined with remarkable sharpness.

Psoas magnus.—(Fig. 31, *b*, and fig. 32, *n*.) A stout pyriform muscle, partially pinnatiform, arising fleshy from the sides of the bodies and the transverse processes of two or three lumbars next above the top of the ilium, and the two sacral vertebræ. It is inserted by a stout rounded tendon into the trochanter minor, blending more or less with the tendon of the iliacus. Fleshy fibres continue almost to the insertion on the posterior aspect of the muscle; on the anterior, a tendinous expansion reaches half way up.

Iliacus.—(Fig. 32, *m*, and fig. 31, *a*.) A rather narrow, elongated and slightly curved muscle, arising from the tip and expanded face of the bone, between the psoas and glutæus mimimus; the usual insertion, by a flattened tendon, with the preceding, into the trochanter minor. Flexion and outward rotation of the thigh, as usual.

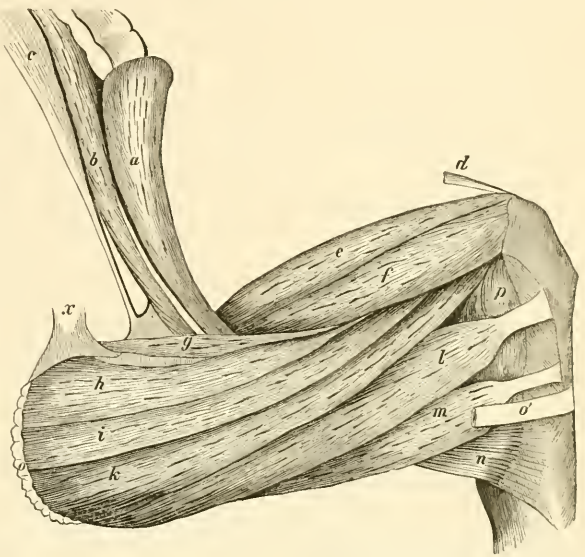


Fig. 31.—Inner aspect of left leg — thigh flexed, rotated inward and strongly abducted, so that the iliacus and psoas muscles are brought nearly in the same plane; nearly natural size. *x*, the os marsupiale.

Glutæus maximus.—(Fig. 32, *k*.) Remarkable for its great superficial extent, and at the same time for its extreme thinness. Its ordinary character, as a fleshy "mass," is changed to that of a layer muscle; its texture is not very appreciably coarser than that of surrounding muscles; nor is it divided into bundles by inward prolongations of the fascia covering it. It forms a wide-spread, thin plane, arising from the tip of the ilium, and by a broad aponeurosis (the fascia over the caudal extensors) from thence to a point of the vertebral column opposite the tuberosity of the ischium. Its anterior border is, as it were, tucked under, and continuous with the glutæus minimus, by complete blending of muscular fibres. The relation of its posterior border to the femoro-coccygeus is described below. From such broad origins the muscle converges, fan-shaped, to the trochanter major, passes over the latter, and is inserted into the ridge on the back of the femur for an inch (and sometimes much more) below the head of the bone. The line of traction of this muscle makes it only a feeble extensor of the thigh; it chiefly abducts and everts.

Glutæus medius.—(The dotted line in fig. 32 shows the extent of the muscle.) This is the most bulky of the three. It arises fleshy from the dorsum of the ilium (all that part not occupied by the succeeding), and by aponeurosis from a corresponding extent of the vertebral column, separating the lateral caudal extensors. It is inserted into the apex of the great trochanter, between the other two glutæi, by a short, stout, flattened tendon. It flexes, abducts, and inverts the thigh.

Glutæus minimus.—(Fig. 32, *l.*) Smallest and most anterior of the three; the only one that arises wholly from the ilium. It takes origin from the common tendon at the tip of the ilium, from the prominent ridge along the anterior border of the bone, and from the flat expansion of bone inside this ridge near the head of the femur. Its anterior border meets and blends with that of the glutæus maximus, thus enclosing the medius, and is in apposition with the iliacus. It has an extensive insertion into the apex of the great trochanter; its action is much the same as that of the foregoing.

Femoro-coccygeus.—(Fig. 32, *h.*) In the course of numerous dissections I have found considerable variation in this muscle—if it really be a distinct one. Sometimes it is scarcely demonstrable as distinct from the glutæus maximus; its aponeurosis of caudal origin being directly continuous with that of the glutæus; its fibres lying in precisely the same plane; its anterior border scarcely separable from the posterior border of the glutæus; its femoral insertion appearing like a direct continuation, along the bone, of the glutæal insertion. In such cases it expends itself upon the femur without reaching the head of the tibia, or, at most, only a fascial or aponeurotic extension attains the knee. When most distinct it is separated by a delicate fascia, or a cellular interspace, from the posterior border of the glutæus; and near its origin its fibres may not lie quite parallel with, or even may overlap, those of the glutæus. It then proceeds, with little or no proper attachment to the femur, to the leg; its posterior border runs along the upper border of the biceps; its crural insertion is by a broad aponeurosis, common to it and to the biceps, into the fascia over the leg, just below the knee. The muscle is always flat and very thin; at its origin it may be an inch or more broad; it narrows before passing the trochanter, and in the rest of its extent it is only a third or a fourth of an inch wide. It extends the thigh and flexes the leg; secondarily, it subserves somewhat to the lateral motion of the tail. Either this muscle, or the one below described as "cruro-coccygeus," is the homologue of what is called the "musculus accessorius a caudâ ad tibiam tendens," in the *Ornithorhynchus*.

Pyriformis.—This muscle is of comparatively large size, and has the shape that has given it its name in anthropotomy. It is covered by the glutæus medius, appearing just under the posterior edge of this, when the maximus is reflected. It arises from the transverse processes of two or three vertebræ, immediately following the synchondrosis, running obliquely outward and backward across the sciatic notch and body of the ilium, in front of the origin of the ischio-coccygeus, and across the hip joint, to be inserted into the very apex of the trochanter major, in intimate relation with the tendon of the glutæus medius, but distinct from that of the obturator internus.

Quadratus femoris.—Of much the same shape and relative size as in man, arising from the ischium next above the adductor, with a broad, fleshy insertion into the back and lower part of the trochanter major, and smooth space between this and the trochanter minor. It extends and everts the thigh.

Obturator externus.—Much larger than the other; a thick rounded muscle, corresponding to the contour of the ischium and pubes, occupying the surface of the bone and foramen. It is inserted by a stout, narrow tendon, somewhat terete, into the lower part of the digital fossa.

Obturator internus.—A thin plane of fibres, rounded in contour, occupying and arising from the whole inner face of the bone, and obturator membrane. Its tendon, which has decided traces of the peculiar digitated structure so beautifully shown in our own, curves

around the border of the ischium, just in front of the ischio-coccygeus, and, receiving the gemelli, proceeds to be inserted into the digital fossa.

Gemelli.—The accessory muscles of the foregoing are well developed, lying along either border of the tendon, distinct from each other above, blended together below. They arise from the edge of the ischium, and are inserted into the tendon near the insertion of the latter.

Ilio-femoralis.—(*Scansorius* Traill.) Besides the preceding six little muscles about the hip joint, there is another and very curious one. It is a small, very slender fasciculus, arising from the upper border of the acetabulum alongside the origin of the rectus, running straight down over the front of the joint, and there curving a little inward to gain, and be inserted into, the base of the trochanter minor. It thus lies in precisely the position of that anterior longitudinal ridge, produced by thickening of the capsular ligament, known in human anatomy as the "ligamentum ilio-femorale." In the present instance this ligamentous ridge does not exist. It is undoubtedly the same muscle as that described by Traill in the ape, under the name of *Scansorius*.

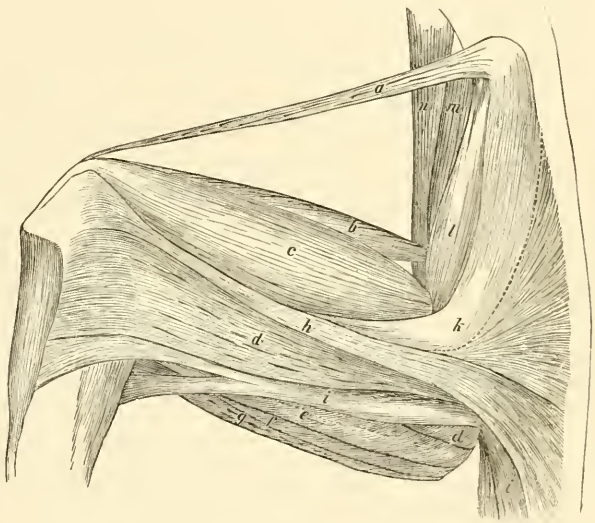


Fig. 32. — Muscles of the left leg, outside — about four-fifths natural size.

There are four flexors of the thigh and extensors of the leg—the sartorius, rectus, and two vasti; and, likewise, four proper extensors of the thigh and flexors of the leg — the gracilis, semitendinosus, semimembranosus and biceps. To the latter, however, must be added the femoro-coccygeus, when fully developed; and also the muscle below described as the cruro-coccygeus. The last named divides into two distinct slips, with opposite insertions in the leg; so that there are really seven leg-flexing tendons that come down along the back of the thigh. The remarkable disposition of these is shown in the accompanying figures. Great flexing power is insured by their low insertions; and rotation of the knee is subserved by their peculiar relation to each other. There are three adductors, which, however, act chiefly as extensors, and a pectineus, which is really an adductor. The contour and disposition of all the muscles is such that the thigh is very thin from side to side, and very deep antero-posteriorly. The bulk of muscle upon the back of the thigh preponderates over that upon the front almost as much as the calf-muscles do over those of the anterior region of the leg.

Sartorius.—(Fig. 32, *a*, and fig. 31, *d*.) A rather slim, flattened ribbon stretched be-

tween the apex of the ilium and the front of the knee, with no relation of contiguity in its course with any of the other muscles of the thigh. It arises by an aponeurosis from the top of the ilium, gradually narrows as it descends, and is inserted aponeurotic into the top and inner border of the "ligamentum patellæ." The peculiar office of the human tailor-muscle is not fulfilled in the least. The action is that of simple extension of the leg, and flexion of the thigh.

Rectus.—(Fig. 32, *b*, and fig. 31, *e*.) No femoral attachment to represent a cruræus. It lies in a bed formed by the vasti; blending with them is prevented by a fibrous investment along its whole under surface. It forms a stout, terete, fusiform belly, arising by a short, stout, flattened tendon from the border of the ilium just above the acetabulum.

Vasti.—(Fig. 32, *c*, externus; fig. 31, *f*, internus.) The two are inseparably blended for their whole length. The outer mass is much the larger, and also longer than the other; somewhat fusiform in general shape, but compressed; arising from the trochanter major, and outer half of the whole shaft of the bone, as far around as the insertions of the glutæus maximus and adductors, and quite to the condyle. The internus is rather pyriform in shape, arising from the rest of the shaft, from the neck to the inner condyle.

The conjoined tendon of the vasti and rectus does not embrace a distinct patella; a little speck of ossification, or several gritty particles, may, however, be found in old subjects. In this instance, at least, the tuberosity of the tibia is an olecranon. The tendon is about a quarter of an inch broad, occupying the groove between the condyles, and proceeding to the usual insertion. On either side it blends with the common capsular ligament, and aponeuroses of the two upper crural flexors. The homotypy of the rectus and vasti together with the triceps of the arm, is here even more strikingly displayed than in man. The rectus is the scapular head; the blended vasti are the similarly conjoined humeral heads. The sartorius as forcibly calls to mind the epitrochlear slip from the latissimus dorsi.

Gracilis.—(Fig. 32, *g*, and fig. 31, *o*, *o'*.) Largest of the crural flexors, and the most posterior as well as internal; a powerful flexor of the leg, and in less degree an adductor of the whole limb. It arises broad, thin and fleshy, from the whole of the symphysis pubis, between the articulation of the marsupial bone and the margin of the semimembranosus. It lies at first upon the adductors, and afterwards upon the crural flexors. At its origin it is an inch or more wide; it narrows very gradually to near the insertion, and is then suddenly reduced to a narrow, flat tendon, which passes across the inside of the leg, to be inserted into the crista tibiæ at the junction of the middle and upper thirds of the leg, just below the insertion of the semitendinosus.

Semimembranosus.—(Fig. 32, *f*, and fig. 31, *l*.) The origin of this muscle occupies the margin of the ischium between that of the preceding and following. But though it thus arises lowest down of any, it is inserted the highest up on the leg, crossing the semitendinosus in its course. It has nothing of the character indicated by its name, being a continuous fleshy belly of large size, prismatic, or almost semilunar in transverse section—the lower border of the adductor magnus lying in the longitudinal groove thus formed. Its short, narrow, and very thin tendon is inserted into the prominence on the inner side of the head of the tibia.

Semitendinosus.—(Fig. 32, *e*, and fig. 31, *m*.) Arises by a short, stout tendon in common with the biceps from the tuber ischii, forming a stout, flattened band that proceeds straight to the leg, to be inserted into the inside of the shaft of the tibia an inch below the

joint—just above the insertion of the gracilis. The fleshy part suddenly contracts into a narrow, flat tendon, about an inch long. The muscle lies at first along the lower border of the biceps; and afterwards crosses the semimembranosus diagonally. Near the middle of its course there is a slight contraction, produced by a partial tendinous intersection; the cruro-coccygeus here effects the remarkable inosculation about to be described. In general characters this muscle most resembles the semimembranosus of anthropotomy.

Cruro-coccygeus.—(Fig. 32, *i*, *i'*, fig. 31, *n*.) This singular muscle arises from the transverse process of the third coccygeal vertebra, by a distinctly marked, short, narrow, flat tendon, and runs, as a flattened fleshy band of moderate size, directly transverse, past the tuberosity of the ischium, along the posterior border of the semitendinosus, with which it is in close apposition. It represents the posterior border of the thigh. At the constriction of the semitendinosus just mentioned, it dips into the substance of the latter, and the fleshy fibres of the two are completely blended. Separating again almost immediately after this inosculation, the muscle divides into two slips that diverge from each other, one proceeding to the inner, the other to the outer, side of the leg. The outer fasciculus, on reaching the leg, ends in a broad, thin aponeurosis, directly continuous with the aponeurotic tendon of the biceps, and is lost in the general fascia of the leg. The inner slip proceeds to be inserted near the tendon of the semitendinosus into the shaft of the tibia. Acting from the tail, this muscle is a flexor of the leg and extensor of the thigh; the occasion for its presence may be found in the necessity for an aid to, and increase of the power of the other muscles of the same set, to enable the animal the more readily to use its hind legs in regaining an ordinary position when suspended by the tail. Its two insertions appear to relate to those rotatory movements of the limb that begin at the knee and culminate at the ankle; when acting together they antagonize each other, and result in simple flexion.

Biceps.—(Fig. 32, *d*, *d*.) The fibular flexor of the leg has none of the characters that suggested its name in human anatomy. Its "short" or femoral head is wanting; it has no connection whatever with the femur. It arises from the tuber ischii by a short, stout tendon, common to the semitendinosus; it is separated from the femur by the quadratus femoris and adductor magnus; the continuation of the femoro-coccygeus separates it from the vastus externus. Beyond the insertion of the glutæus maximus, the biceps is in intimate relation, by its upper border, with the femoro-coccygeus; the aponeurotic insertion of the latter into the leg is a part of the expansive tendon of the biceps. Similarly, the lower border of the biceps is in relation with the cruro-coccygeus, after the latter has inosculated with the semitendinosus, and the aponeuroses are completely blended. The biceps becomes thinner and wider as it proceeds to the leg, almost covering all the other flexors in the lower part of its course; and finally expands into a very broad and thin aponeurosis, which, blended above and below with the similar fibrous expansions of the two coccygeals, covers the outside of the leg from the knee nearly half way to the ankle. This fibrous lamina has no direct insertion into the fibula; it may readily be lifted in its entirety from this bone, and traced around the leg as far as the crest of the tibia, which is its real final attachment. It becomes lost, in fact, in the common fascia of the leg, and ligaments of the knee joint. The diffuse indefinite insertion of the three flexing tendons on the outside of the leg is in striking contrast to the rigidly determined and exact insertion of the four that pass to the inner side. The want of two distinct heads of this crural flexor heightens its similarity to the corresponding muscle of the arm. The resemblance is increased in a

curious manner by its virtual insertion into the tibia instead of the fibula, just as one part of the biceps of the arm is inserted into the ulna instead of the radius.

Pectineus.—(Fig. 31, *g.*) This is the smallest, shortest and uppermost of the adductorial set. It is a somewhat flattened fusiform muscle, arising by a very short, terete tendon from the outer border of the base of the marsupial bone, and inserted by a short, thin tendon, an inch broad, into the posterior aspect of the femur for a corresponding distance below the trochanter minor. It is a true adductor of the thigh; acting from the femur it draws the marsupial bone out from the belly and away from its fellow, antagonizing the pyramidalis. Sometimes it is double, *i. e.*, may be separated into two perfectly distinct parallel slips, with common origin, and directly continuous insertion. Its origin may be indicative of analogy, if not homology, between the marsupial bone and the "linea ilio-pectinea" of man.

Adductor parvus.—(Fig. 31, *h.*) The shortest of the three, but rather more bulky than the longus, which it separates from the magnus in one plane, and from the pectineus in another. It arises fleshy from the symphysis and border of the ramus of the pubis, separated from the extreme margin of the bone by the origin of the gracilis and the pubo-marsupial articulation, occupies the distance between the marsupial bone and the origin of the longus, and is overlaid in most of its extent by the pectineus and gracilis. Its short, thin, flat tendon, nearly an inch wide, is inserted into the femur between the pectineus and the longus. This muscle is the most decidedly adductorial of the three.

Adductor longus.—(Fig. 31, *i.*) A long, narrow, flat slip, lying in the same plane with the preceding, with the border of which it is in complete apposition. It arises from the symphysis pubis along the space between the origins of the preceding and following muscle, and is overlaid, in most of its extent, by the broad gracilis. It is inserted fleshy into the back part of the femur, from the insertion of the pectineus to within an inch of the inner condyle.

Adductor magnus.—(Fig. 31, *k.*) Much the largest of the three, forming a complete fleshy septum between the pubic and ischiatic sets of muscles. It is trapezoidal in outline; its lower border is much thickened. It arises from the whole of the lower border of the pelvis, from the tuberosity of the ischium to the symphysis pubis, along which extent its origin is overlaid successively by the biceps, semitendinosus, semimembranosus and gracilis. It is inserted fleshy into the whole length of the femur from a point opposite the trochanter minor, or just at the insertion of the quadratus, to the origin of the inner gastrocnemius. It is more of an extensor than adductor of the thigh. It may frequently be partially separated into two or three flattened bundles. In fact, the three adductors, having a continuous origin and insertion, and parallel contiguous course, appear in some instances to exchange fasciculi with each other. With exercise of the same care in dissecting in each instance, I have on several occasions worked out these muscles a little differently. The longus appears most variable, as it holds an intermediate position. The usual condition is as above described.

The noteworthy features of the muscles of the leg are numerous and interesting. The general disposition relates unequivocally to those rotatory movements that are equivalent to pronation and supination of the member, and to that grasping power of the extremity that transforms the latter to a true "hand." The muscles display the pedimanous character of the beast as clearly as does the nature of the articulation at the knee, ankle, or toe. There are two gastrocnemii, perfectly distinct from each other, with separate tendons and different insertions. The soleus is confined to the external gastrocnemius; it has no proper

tendon. The plantaris is large; its tendon forms a third tendo achillis. There is no popliteus. The long flexor of the toes lies upon the fibular, and the long flexor of the great toe upon the tibial, side of the leg. The peroneus longus has two insertions; the peroneus "tertius" is found as the proper extensor of the little toe. The "short" extensor of the toes, instead of lying upon the dorsum of the foot, comes down from the leg above, as one of the peroneal group, whose tendons pass behind the external malleolus; one fasciculus of it is left upon the instep, constituting the short extensor of the great toe. In like manner the "short" ("perforatus") flexor of the toes extends some distance up the leg upon the conjoined tendon of the long flexor, from which it takes origin. A curious arrangement of the flexing muscles of the great toe occurs.

Study of the muscles of the leg is facilitated by considering them in four groups: first, the anterior tibial—those that pass over the instep; second, the fibular—those that pass behind the external malleolus; third, the superficial posterior tibial—those that pass to the heel; fourth, the deep posterior tibial—those that pass behind the internal malleolus, or rather, over the heel, to the foot, including also the interosseus cruris.

Tibialis anticus ("*flexor tarsi tibialis*").—(Fig. 33, *b*.) By far the largest muscle of this region; the fleshy part is of a somewhat prismatic shape, and extends along three-fourths of the leg. It arises from the head and upper third of the fibular side of the tibia, and intermuscular septum between itself and the common long digital extensor. Its stout, flattened tendon crosses the instep, just in front of the inner malleolus, bound down by the annular ligament, passes obliquely to the inner side of the foot, there to be inserted into the internal cuneiform bone (not base of first metatarsal). It has the usual action.

Extensor proprius pollicis longus. — (Fig. 33, *d*.) Deep-seated, and covered by the preceding and following muscle. A long, slender, fusiform belly, arising from the upper half of the tibial aspect of the fibula, somewhat blended with the short digital extensor, changing to a slender, flattened tendon just above the ankle, passing beneath the annular ligament, and thence proceeding very obliquely across the instep to gain the great toe, run along the latter, and be inserted into the base of the distal phalanx.

Extensor communis digitorum longus.—(Fig. 33, *c*.) A small muscle, overlying the preceding, arising from the head of the fibula in common with the peroneus brevis. Its muscular part is only two or three inches long; it rapidly divides into *four* parts, representing as many tendons These pass as one down the leg until they emerge from beneath the annular ligament, when they diverge to the four lesser toes, into the base of the ungual phalanges

Fig. 33.—Anterior tibial and fibular view of the left leg and foot; natural size. *a*, vastus externus.

of which they are inserted. The tendon of the middle toe often splits, to give off a slip to the second toe, which is thus doubly supplied.

Extensor communis digitorum brevis s. accessorius.—(Fig. 33, *k*, only the tendons shown.) As already intimated, this muscle, which in anthropotomy is found upon the dorsum of the foot, is here carried up the leg; only the pollical fasciculus being left upon the instep. It belongs to the fibular group. It is a diminutive muscle that arises from the upper part of the fibula for an inch or so below the head of the bone, more or less blended with the extensor longus pollicis, and covered by the peronei. In its whole course it lies close to the fibula, passes behind the external malleolus, and then immediately splits into *three* tendons, that pass to the second, third and fourth toes. These tendons are extremely attenuated, and run very obliquely across the instep, beneath the tendons of the preceding. Each runs along the fibular side of a toe, to be inserted into the base of the second (middle) phalanx. As the tendon that goes to the fourth toe passes the fifth metatarsal, it gives off a delicate slip to the little toe, which then has two extensor tendons besides its own from the peroneus tertius.

Extensor brevis pollicis.—(Fig. 33, *i*.) This detached remnant of the preceding, as it seems to be, though not lying upon the leg, may be most conveniently noticed in this connection. It is the only muscle upon the dorsum of the foot; it is devoted exclusively to the great toe, but occasionally gives off a little thread-like tendon to the second toe. It is a diminutive, fleshy fasciculus, lying diagonally across the instep from the external malleolus; its delicate tendon runs to the base of the distal phalanx of the great toe, alongside the tendon of the extensor longus pollicis.

Peroneus tertius, s. extensor minimi digiti.—(Fig. 33, *f*.) While the third peroneus of anthropotomy is sometimes wanting, and at best is little more than a part of the long common digital extensor, passing with the latter over the front of the ankle to reach the base of the fifth metatarsal, it is here found well developed, and in what appears to be its real character as a member of the fibular group, and the proper extensor of the little toe. Although small, it is a perfectly distinct muscle, arising from the head of the fibula, overlaid by the peroneus longus. The fleshy part is about an inch long, and forms a flattened spindle. The very long and exceedingly delicate tendon passes along the fibula, behind the external malleolus, along the external border of the foot, to be inserted into the base of the ungual phalanx of the little toe. It has also some attachment to the base of the little toe, but none to the fifth metatarsal.[1]

Peroneus secundus s. brevis.—(Fig. 33, *e*.) Very slender, fusiform, muscular for rather more than half its length, arising in common with the long digital extensor, distinct from,

[1]Anatomists differ as to the homology of the three muscles last described. If the fasciculus upon the dorsum of the foot be recognized as the whole of a rudimentary extensor digitorum communis brevis s. accessorius, the one above described under this name should rather be regarded as the peroneus tertius; and the extensor minimi digiti as a distinct muscle from the latter. Among other things that seem to favor this view (independently of the fact that actual dislocation of the parts of a morphologically simple muscle is rare, and therefore improbable in any given seeming instance), it may be stated that the extensor brevis of man only gives one tendon (that of the great toe) to be actually inserted into a digital phalanx, the other three blending with the corresponding tendons of the long extensor before insertion; and that, in the present example of the opossum, the fasciculus in question does really, at times, if not ordinarily, send another tendon to the second toe, thus allowing the inference that sometimes the third and fourth tendons may be developed. Should the muscle be found with these four tendons, its homology would be plainer. Moreover, even the third peroneal of man, despite its metatarsal insertion, appears to partake more of the character of a digital extensor, and may be therefore an undeveloped condition of the same muscle that is above described as the short or accessory

and anterior to, the long peroneal. It lies at first upon the preceding muscle and extensor of the great toe; afterwards upon the fibula, alongside the following muscle. Its flattened tendon passes behind the external malleolus, and thence straight to its insertion at the outside of the base of the fifth metatarsal.

Peroneus primus s. longus.—(Fig. 33, *g, g.*) The largest and most superficial of the peroneal group; a long, flattened spindle, muscular nearly to the ankle. It arises from the outermost part of the head of the fibula, and for a short distance from the shaft of the bone, and from the surrounding intermuscular septa. After passing behind the malleolus its short tendon dips obliquely forward, outward and downward, to gain the side of the foot; is there reflected around the cuboid, passes through a deep groove (converted by ligament into a sheath) in the under surface of the latter, runs obliquely across the sole, along the bases of the conjoined metatarsals, and is inserted into the outer side of the base of the first metatarsal. Opposite the base of the fifth metatarsal it gives off a short slip to be there inserted. It has the usual action, flexing and elevating the side of the tarsus, in the former respect coöperating with, in the latter counteracting, the tibialis anticus. The peroneus brevis and extensor longus pollicis assist, respectively, the peroneus longus and the tibialis anticus, in the lateral movements of the ankle joint. These four muscles, and the extensor of the digits, collectively oppose, by flexing the tarsus, all the remaining muscles of the leg.[1]

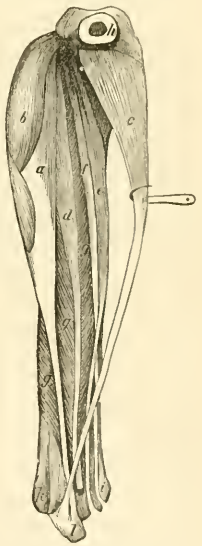


Fig. 34.—Left leg, posterior view; natural size.

Gastrocnemius internus.—(Fig. 34, *c.*) This is entirely distinct from the external gastrocnemius and soleus, having separate insertion as well as origin, and no relation in its course except that of contiguity. It has extensive origin by a prismatic, fleshy head from the internal condyle, and greater part of popliteal space of femur, across to the outer condyle. About an inch and a half below the knee it suddenly contracts to a stout, flat tendon, which at the lower third of the leg crosses behind (outside) the tendon of the other gastrocnemius, to be inserted alongside the latter into the outer and lower corner of the tuberosity of the os calcis.

Gastrocnemius externus and *Soleus.*—(Fig. 34, *a* and *b*, and fig. 33, *h.*) The outer muscular belly of the calf is much larger than the other, and of complex structure, apparently resulting from blending with a soleus. Its three parts are disposed thus: A flattened ovate or split almond-shaped mass arises from the external condyle,

digital extensor. Per contra, however, the human peroneus tertius may be an arrested extensor minimi digiti.

Again, the extensor of the opossum's little toe may be, morphologically, a part of the fibular muscle that supplies the next three toes; the two parts, then, together constituting the peroneus tertius. This second mode of viewing the subject leaves us free, as in the first instance, to identify the slip upon the dorsum of the foot as the whole of the flexor brevis digitorum, in a rudimentary condition.

With this explanation I allow the above descriptions to stand just as they were penned at the times of making the dissections.

[1] Prof. Owen thus describes the peroneal muscles of *Dasyurus macrurus* (op. cit., p. 16): "There are three peronei: the external one is inserted into the proximal end of the fifth metatarsal; the tendon of the middle peroneus crosses the sole in a groove of the cuboid, like the peroneus longus; the internal peroneus is an extensor of the outer or fifth toe." Of these, the first mentioned, or "external" peroneus, is the one described above as the *p. secundus* seu *brevis*; the next, or "middle" peroneus, is the *p. primus* seu *longus*, of this paper; while the last, or "internal" peroneus is the *p. tertius*—according to my identification.

at the termination of the vastus, lies upon the soleus, and blends with the latter far above where the same becomes tendinous; it is the superior and posterior, or superficial portion. Just below, and a little to the outer or fibular side, lies another smaller mass, taking origin exclusively from the surface of the soleus, with which it blends below. The soleus proper consists of two heads, the most posterior or superficial of which arises from the fibular sesamoid fabella and lateral knee joint ligament, and slightly from the external condyle; the most deep seated from the head of the fibula, between the peroneus longus and long digital flexor. The compound muscle, so constituted, forms a great protuberance, deep antero-posteriorly, narrow from side to side; tapering gradually as it descends, becoming tendinous a little below the middle of the leg, and then soon crossing inside (in front of) the tendon of the preceding, to be inserted into the inner lower corner of the tuberosity of the os calcis. Thus there are two perfectly distinct tendones achillis, without counting the plantaris as one. This muscle has no connection with the tibia. Is it likely that the politæus (no traces of which as a distinct muscle can be found) is represented by one of the divisions described?

Plantaris. Tensor fasciæ plantaris.—(Fig. 34, *d.*) Well developed, of large size, arising from the fibular fabella, distinct from the foregoing. It is a flattened muscle, becoming tendinous at the lower third of the leg. Its tendon passes along the inner border of the inner tendo achillis, lying upon the tendon of the flexor longus digitorum. It begins to become fascial above the heel, passes over the latter just inside of the os calcis, and is continued along the sole as the plantar fascia.

Flexor communis digitorum longus.—(Fig. 34, *g, g, g,* its muscular part, and fig. 35, *a,* its tendons.) This is the flexor perforans seu profundus, as proved no less by its own physical characters than by the relation that the short flexor of the toes bears to it. It lies upon the fibular side of the leg — exchanging places with its flexor longus pollicis, as far as anthropotomical relations are concerned. It is much the largest of the four muscles constituting the deep layer of the posterior set. It is bipinnatifid, and has a groove along its inner aspect in which the fibula lies partly embedded. It arises from the head and nearly all the shaft of the bone, blended somewhat above and on the inner side with the tibialis posticus. Just above the heel it becomes tendinous; a fibrous expansion of the tendon runs up the surface of the muscular part nearly to the head. The tendon—very short and much flattened—passes the heel in the deep notch between the os calcis and inner malleolus; and just at the middle of the sole disengages *four* tendons, that at once diverge to the four lesser toes. The conjoined tendon cannot be subdivided higher up; it is a single dense fibrous band. Each tendon lies upon the under surface of a toe, enclosed in a sort of sheath formed by lateral expansion of the tendon of the muscle next to be described, at length perforates the latter, and finally is inserted into the base of the distal phalanx. These tendons are quite stout, and flattened; each, in passing the continuity of the medial phalanx, is closely bound down by a distinct, strong, transverse, fibrous band. Before its division the large common tendon is joined by the tendons of the flexor longus pollicis, and the flexor brevis pollicis obliquus. The accessory muscles (lumbricales) are described further on.

Flexor digitorum "brevis." Flexor sublimis s. perforatus.—The homotypy of this muscle with the corresponding one of the hand, is not only proved by its relations to the long or profound flexor of the foot, but is further carried out, in a very interesting way, by the fact that, instead of being confined to the sole, as in anthropotomy, it arises above the heel, part way up the leg. The occasion for this prolongation of the muscle above the heel may be of a part with that which determined the similar extension of its antagonist, the

extensor brevis digitorum, still higher up to the knee. (See, however, foot note on page 130). Instead of arising from the os calcis and being wholly a plantar muscle, as in man, this short flexor arises fleshy from, and lies upon, the common tendon of the long flexor, an inch or more above the heel. At the point in the sole where the long flexor tendon subdivides, this one also splits, likewise into four tendons, that pass one to each of the four lesser toes. The fasciculus going to the second toe is more or less distinct from the rest, and lies wholly or in part upon the tendon of the flexor longus pollicis. These tendons are all excessively delicate; those going to the second or third toes are the longest; fleshy fibres accompany the tendons to the base of the fourth and fifth toes. Each tendon at the base of a toe gives off on either side fascial expansions, that bind it to the common sheath of the toe, and embrace the heavy tendon of the deep or long flexor. Further on, each tendon splits, embracing again the deep tendon, and proceeds to be inserted into the base of the second phalanx. The lumbricales appear to belong almost as much to this set of tendons as to the deep ones.

Flexor longus pollicis.—(Fig. 34, *e*, and *b*.) A small flattened, fusiform muscle, arising from the head and outer aspect of the shaft of the tibia, and the intermuscular septum between itself and the tibialis posticus. Its long, slender, flattened tendon runs along the inner border of the tendon of the latter, passes in a groove behind the extremity of the tibia, gaining the sole of the foot, where it lies along the inner border of the flexor longus digitorum. It does not, however, proceed to the great toe, but is inserted into the tendons of the flexor longus digitorum and flexor brevis obliquus pollicis, just where the two latter become blended together. These three tendons thus fuse at a common point. Nature seems to have repented of making this animal's foot so much like a hand, and to have incontinently tied the two flexor tendons of the great toe to the common tendon of the other toes, so that this opposable digit cannot have other independent flexion than that afforded by the little muscles upon its ball.

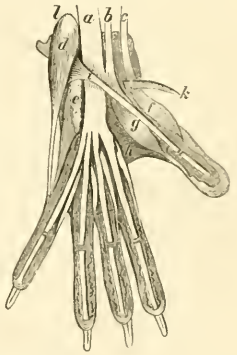


Fig. 35.—

Tibialis posticus (*extensor tarsi tibialis*).—(Fig. 34, *f*, and fig. 35, *c*.) A small muscle with a short belly, lying deep seated between the foregoing and the long digital flexor. It arises from the inner part of the head of the fibula, contiguous part of shaft of tibia, and intermuscular septum betwixt itself and the foregoing muscle. Its tendon, twice as long as the fleshy part, passes behind the internal malleolus, on the tibial side of the flexor longus digitorum, to be inserted into the inner side of the scaphoid.

Interosseus cruris. (*"Pronator fibulæ quadratus."*)[1] The interosseous space between the bones of the leg is occupied, from knee to ankle, by a plane of obliquely transverse fibres, situated between the two layers of the interosseous membrane. The direction of the fibres decussates with that of the aponeurotic fibres; and, particularly on the lower part of the front of the leg, the aponeurosis is very strong, dense and glistening. Though the muscle, as a matter of fact, cannot really pronate the limb, its action is in this direction;

[1] Prof. Owen (Comparative Anatomy and Physiology, iii, p. 15) says of this muscle, in the case of *Dasyurus macrurus*, that it "may be the homologue of the flexor digitorum communis;" and in the same animal he considers the muscle that sends flexor tendons to all the toes except the rudimental hallux, as the flexor longus pollicis.

it subserves the motion of the two bones upon each other, and may be the homotype of the pronator radii quadratus. The peculiar construction of the gastrocnemii and the relations of their tendons, has probably something to do in producing, or in aiding in the production of, the movements of the tibia and fibula upon each other.

The only muscle upon the dorsum of the foot has been already described. The plantar muscles are large and numerous, consisting of lumbricales, interossei, and the several special muscles of the great and little toes. The flexor brevis digitorum accessorius and transversus pedis, of anthropotomy, are wanting; the abductor pollicis is scarcely demonstrable as distinct from the flexor brevis pollicis. There is a calcaneo-metatarsal muscle not found in man. The chief flexor of the great toe has a curious disposition, of which I have seen no previous account.

Lumbricales.—(Fig. 35, seen attached to the tendon, *u.*) Four in number, all well developed. The first lies upon the tibial side of the tendon of the second toe; the others arise from the bifurcations between the other three tendons; all have intimate connection with the tendons of the superficial digital flexor. They form little terete bellies, each with a long, slender tendon, that runs along the inner side of a toe to the base of the second phalanx, where it is inserted.

Flexor brevis pollicis.—(Fig. 35, *f* and *g.*) This forms the chief ball of the great toe. It lies upon the first metatarsal, and consists of distinct halves, separated from each other by the stout tendon of the muscle next described. The two bundles lie parallel with each other, and are inserted respectively into the inner and outer sides of the base of the first phalanx. Each one embraces a sesamoid bone. The outer half has extensive origin from the inner surface of the closely appressed cartilaginous spur. This muscle might possibly be regarded as two, and the outer part be taken to represent an abductor s. opponens pollicis. But the action of the two halves is the same—simple flexion.

Flexor brevis pollicis obliquus.—(Fig. 35, *i.*) The great toe has another short flexor; a distinct and very curious muscle, that I shall have to describe under this name, not knowing what, if any, name it has already received. It arises by a short, stout, fleshy head from the whole of the depression on the outer (fibular) aspect of the os calcis. It curves around the lower border of this bone, between it and the short muscle of the little toe, and then suddenly contracts to a stout, flattened tendon, that traverses the sole diagonally (parallel with the course of the peroneus longus tendon). As it crosses the conjoined tendon of the flexor longus digitorum, it is firmly attached to the inner (tibial) side of the latter, just at the point where the flexor longus pollicis is similarly attached; it is, moreover, inseparably connected with the last named. Without losing its individuality by the blending of these tendons with it, it continues on to the first metatarsal, where it lies deeply embedded between the two parts of the muscle last described. Emerging, it finally passes to be inserted into the base of the last phalanx of the great toe, of which it is the chief and proper flexor. As it passes the first phalanx it is bound down by a distinct, stout, transverse band. While the flexor profundus digitorum of the hand has five tendons, one for each digit, the corresponding muscle of the foot has lost its pollical tendon, unless we can find it in this muscle. I am inclined to regard it as the displaced pollical fasciculus of the common long flexor of the toes. Notwithstanding its peculiar origin and diagonal course, it is inseparably connected with the tendon of the common digital flexor; and, moreover, the size and general appearance of its tendon, and particularly its mode of connection with the great toe, are precisely the same as those of a tendon of the digital flexor. In opposition to this view,

however, it should be stated that the flexor longus pollicis of the hand is absent, or at least sends no tendon to the thumb, the fifth thumb tendon of the hand resulting from the confluence of this muscle with the common digital flexor; and that, as we have seen above, the flexor longus pollicis of the foot is present as a distinct muscle, only its tendon is arrested on its way to the great toe, and tied at the end to the tendon of the common flexor. Furthermore, in view of the connection of this oblique tendon with the tendon of the flexor longus pollicis, the muscle in question might be regarded as an accessory of the latter.

Adductor pollicis.—(Fig. 35, *h.*) A thin, fan-shaped plane of fibres, lying below the level of the interossei, stretching between the second and first metatarsals, converging to be inserted with the inner head of the flexor brevis, into the inner side of the base of the first phalanx of the great toe.

Flexor brevis minimi digiti.—(Fig. 35, *e*, cut off.) A thin, triangular plane of fibres of considerable superficial extent, its origin stretching across the foot from the cartilage upon the ball of the great toe to the base and part of the shaft of the fifth metatarsal, and also attached to the plantar fascia. Insertion at inner side of the base of the first phalanx of the fifth toe. This muscle may be found incompletely divisible into two parts, the inner of which would represent an adductor minimi digiti.

Abductor minimi digiti.—(Fig. 35, *d.*) A very distinct muscle, arising by a short, stout, fleshy belly from the under surface of the tuberosity of the os calcis, running along the external border of the foot, to be inserted into the outside of the base of the fifth toe.

Calcaneo-metatarsales.—These are two little flexing, or rather abducting, muscles of the fifth metatarsal itself, arising from the anterior part of the tuberosity of the os calcis, and passing to the outside of the base of the fifth metatarsal. They fill the deep notch between these two points, and floor the sheath through which the oblique flexor of the great toe passes.

Interossei.—The plantar interossei are of great size, forming a thick, soft cushion that fills the concavity of the sole formed by the curved metatarsals from the bases to the apices of these bones. That one upon the tibial side of the second toe is perfectly distinct from the others; the rest are much blended together. The tendons have the usual lateral insertions into the bases of the toes. They mostly embrace sesamoid bones.

PART III.—ON THE ANTERO-POSTERIOR SYMMETRY, OR LONGITUDINAL HOMOTYPY, OF THE MUSCLES OF THE LIMBS.

The foregoing account of the opossum's bones and muscles, as little more than a mere congeries of facts and observations, would appear fragmentary and pointless, were not at least the attempt made to deduce some of those generalizations that belong to the field of philosophic anatomy. In preceding pages certain morphological and teleological questions have been neither specially sought nor avoided, but treated, when they seemed naturally to arise in the course of the investigation, with whatever of light the writer's studies have afforded. Such, notably, have been the considerations touching the morphology of the skull regarded as a series of vertebræ; the correspondences of the bones of the fore and hind limbs; the general homologies of certain muscles, and, more especially, the teleological

correlation of the muscular system with the movements and habits of the animal. It is desired, however, to offer in the present connection, as somewhat of a supplement to what has preceded, some thoughts upon questions of antero-posterior symmetry which have forced attention during the writer's dissections.

"If," as a distinguished anatomist has said, "antero-posterior symmetry can be shown to exist in the bones, then we can feel some confidence that whatever the difficulties at present may be with regard to the muscles, nerves and vessels, they will sooner or later be overcome." We believe that antero-posterior symmetry not only can be, but has been, demonstrated in the bones of the limbs of higher vertebrates, in the sense that, for instance, makes a humerus and a femur mutually correspondent: — the one a reversed representative of the other. Few, if any, anatomists to-day deny the main point, however widely they may differ in the details of their comparisons of fore and hind limbs as symmetrical repetitive parts of the skeleton. And if an arm and a leg are found correspondent as to their osseous structure, it seems to follow — we had almost said as a matter of course—that correspondence, similar in kind if not in degree, exists in the other tissues and organs, surrounding, nourishing, protecting and acting upon the bony framework. Assuming, then, without argument, the existence of special osteological homologies in limbs as a demonstrated fact, we infer similar existence of homology in the muscles, as a logical sequence. But the difficulty of directly proving such an inference to be true, is very great; so great, that the pointing out of muscle for muscle throughout the limbs has not yet been done, and perhaps never will be. *Pari passu* as we advance from the bare skeleton—the simple framework of the body—modifications of an ideal type increase in number and degree of complexity. Teleology may so far overshadow morphology that only glimpses, as it were, of original unity of plan can be discerned in the obscurity; or we may even be left in total darkness. But to the imperfection of our vision, perhaps, rather than to want of the whereupon to exercise it, may be ascribed our shortcoming in this respect; and if only one single ray of light be afforded us, it should encourage us to hope and seek for more. And I believe that we have at least one clear and steady beacon light to guide us in our search for the special homologies of the muscles of the limbs. This is found in the extensor muscle of the forearm and leg. The proposition, which appears almost axiomatic, may be thus stated: — If the humerus and the femur are in any sense correlated and correspondent, then the triceps extensor cubiti and the triceps extensor cruris are in the same sense correlated and correspondent.

Before any attempt is made to determine muscular homologies, a clear understanding of the homology of the several bones of the limbs is obviously necessary. Without repeating the arguments with which anatomists have for so many years defended their conflicting views with more or less success, it will be sufficient to present, in tabular form, the special homology of the bones that will be made the basis of the present inquiry into the corresponding relations of the muscles. Professor Wyman's method of viewing the skeleton is the one followed, except in the case of the coracoid and clavicle, as related to the ischium and pubis; in which instances Professor Owen's determination is adopted. The skeleton is suspended horizontally, the limbs depending vertically, each segment a little flexed, with the forearm supine, and the palm downward. In this position the scapular arch may be considered to point forward, and the pelvic backward; the arm points backward and the thigh forward; the forearm forward and the leg backward; the hand backward and the

foot forward; the palm and sole both resting on the ground. Were another deflected segment allowed, the fingers would point forward and the toes backward; thus they are considered as reversing respectively the directions of the hand and foot. In this position, the axis of each segment points in an opposite direction, both to the homologous segment and its own succeeding segment, the salient angles at the flexures point in opposite directions, as the elbow backward, the knee forward; the front of the whole of one limb, as of its several segments, corresponds to the back of the other, and *vice versâ*: one is the reversed repetition of the other. The radius and fibula, and the thumb and little toe, are all upon the outside. We thus have, as homologous bones —

ANTERIOR EXTREMITY.	POSTERIOR EXTREMITY.	ANTERIOR EXTREMITY.	POSTERIOR EXTREMITY.
Scapula.	Ilium.	Pisiform.	———— ?
Coracoid.	Ischium.	Trapezium.	Cuboid.
Clavicle.	Pubis.	Trapezoid.	3d Cuneiform.
Humerus.	Femur.	Magnum.	2d Cuneiform.
Ulna.	Tibia.	Unciform.	1st Cuneiform.
Radius.	Fibula.	Metacarpals.	Metatarsals.
Scaphoid.	Astragalus.	Phalanges.	Phalanges.
Semilunar.	Os calcis.	Thumb.	Little toe.
Cuneiform.	Navicular.	Little finger.	Great toe.

It cannot of course be denied that there are muscles whose *general* homologies cannot be traced; muscles existing in one species or group of mammals, no indication of which can be found in other species or groups. But this fact does not detract from the pertinency of homologies of other muscles that do exist, and are traceable. The biceps, for example, of an opossum, is not the less the muscle so-called in a man or a monotreme, because an opossum may have muscles that the other two want, or conversely. Muscles are so far under the rule of teleology, that they may be, and are, frequently developed (according to what by-play, so to speak, of morphology we are ignorant) in the face of special emergency, as it were, to act definitely upon a particular organ or part, and are consequently not developed in those animals in which such particular organ or part is either wanting, or so far modified as not to require such muscular apparatus. Similarly — narrowing our range of observation, and turning from general to special homology, the expression of which we would seek in different parts of the same animal as evidence of the further operation of the law of antero-posterior symmetry that is found to hold with the bones—it cannot be denied that we find muscles in the fore and hind limbs that thus far have resisted every endeavor of ours to recognize their correlation; and the probability seems to be that there really are, on either of the pairs of limbs, muscles that have no existence, actual or "potential," in the other—whether as the result of extreme teleological modification, or of morphological difference, we do not presume to say. But such a fact should not be allowed to militate unduly against evidence in favor of a law of fore and hind symmetry; for non-existence of this, or any other law, is not to be assumed because its application to every detail cannot be shown. As far as I know, anatomists never have shown, and they probably never will show, the special homology of the highly differentiated and specialized muscles of the cranial and caudal extremities of the trunk; but this does not necessarily preclude the belief that these parts are reversed repetitions of each other. And it may fairly be assumed, I think, that there is an antero-posterior symmetry in the muscles of the

limbs, if some muscles are demonstrably homologous in the same sense that the femur and humerus are, and many others afford nearly as unequivocal evidence to the same effect; in spite of the fact that some have not, as yet, been shown to be thus correlated.

I do not venture to hope that all — indeed, I scarcely think that most — of the special homologies I shall endeavor to point out will ultimately prove correct; my range of observation has been too limited for this. But even faltering and devious advance, in such a field as this, may be better than a stand-still; something will be gained if any points are firmly established; and even errors themselves may serve some useful purpose when they shall have been pointed out by better informed or more fortunate observers.

Bearing in mind the position and relations of the skeleton already assumed, it will be obvious that homologous muscles are to be sought for on opposite, which are homologous, sides of the limbs; that is, upon the front of the fore and back of the hind, or upon the back of the fore and front of the hind, extremities, in the longitudinal direction; and upon the same side, that is, upon the outer aspect of the arm and outer aspect of the leg, or upon the inner aspect of the arm and inner aspect of the leg, in the transverse direction. There is no known departure from this rule.

Position and relation are of first and last importance in the determination of muscular homologies, and, in fact, afford the only sure guides. For muscles are so variously and complexly modified, teleologically, for special purposes, that their function, or the end they subserve in the movements of a limb, is of all things the least likely to afford correct indications. Even origin and insertion are not infallible indices; for the same muscle varies in these respects within certain limits.

The terms "flexor" and "extensor," as ordinarily used, especially in anthropotomy, are incorrect in their application to certain muscles of the forearm and hand. Primarily, flexion is simply bending, and extension merely straightening, of the segment of a limb with reference to the preceding one; but in precise anatomical language these expressions have come to have an arbitrary and special signification. Still recollecting the assumed position of the limbs as above detailed, in which the axes of all the segments are more or less oblique to each other, "flexion" is the increasing of this obliquity by lessening the internal angles at the joints; and "extension" is the lessening of this obliquity by increasing the internal angles, till they equal 180°, and the several segments are straight with reference to each other's axes, when further extension at those joints where such motion is possible reinduces obliquity, but in the contrary direction to that in which "flexion" acted. Thus "flexor" muscles will invariably be found upon the back of the scapula, forearm and hand, and upon the front of the pelvis, leg and foot; upon the front of the arm and the back of the thigh; while conversely, "extensors" lie upon the front of the scapula, forearm and hand, and upon the back of the pelvis, leg and foot; upon the back of the arm and the front of the thigh. Applying this test, the so-called "flexors" upon the front of the forearm and palmar aspect of the wrist are in reality extensors, and the so-called "extensors" upon the back of the forearm and dorsum of the wrist are really flexors, and will be so designated in succeeding paragraphs, although in what has gone before the ordinary nomenclature has been observed. In reference to the leg and foot the usual interpretation of flexors and extensors is the correct one; the same is the case regarding digits. At the shoulder joint retroduction of the humerus is flexion, and conversely; on the contrary, at the hip joint retroduction of the femur is extension, and conversely. All other

motions of joints are but combinations of flexion and extension; adduction and abduction are only transverse instead of longitudinal flexion and extension; circumduction comprehends both, the distal extremity of a segment describing a curved instead of a straight line; and even simple rotation, as at shoulder and hip, will be found, when closely examined, to be similarly reducible.

The direct action of many flexors and extensors upon a succeeding segment is complemented by an indirect action, whereby they become respectively extensors and flexors of a preceding segment—that one upon which they lie. Such flexors and extensors are those that take origin from a segment above that upon which they lie, and the second above that upon which they primarily and directly act. Thus the biceps, arising from the scapula, is a direct flexor of the forearm, and an indirect extensor of the arm, etc., etc. On the other hand, those that extend over but two instead of three segments, have no such complementary action; thus the brachialis anticus is purely a flexor of the forearm, and if it have any "reverse action," as when it contracts from its insertion as a fixed point, such operation still really tends to continued flexion of the forearm, by means of the flexion (retroduction) of the humerus that is induced. These, and many correlated facts, have been ably elucidated by Professor Wilder, in his paper "On Morphology and Teleology, especially in the Limbs of Mammalia," and been made the basis of a division of limb-muscles into systems of "long" and "short" flexors and extensors; which classification is made to play an important part in his determination of the special homologies, and beyond a doubt affords instructive indications in certain obscure cases.

The foregoing appear to be the principal theorems and definitions that will come into use in the present inquiry.

The scapular arch is loosely appended to the trunk, and enjoys free movement in various directions. With the exception of the loose sterno-clavicular articulation, its attachment is entirely by muscular tissue. The muscles are large, numerous, and varied in form, function and position; they are eight in number, viz.: the cleido-mastoid, subclavius, trapezius, rhomboideus, serratus with levator anguli scapulæ, "atlanto-acromialis," "atlanto-scapularis" (see page 112), and omo-hyoid. Of these eight, the first named may be morphologically a part of the sterno-mastoid, and the second appears referable, with obvious propriety, to the intercostal series. The omo-hyoid has been conjectured to belong to the same series, connecting as it does hæmal arches of contiguous cranial vertebræ—the occipital and parietal. The levator anguli scapulæ and serratus, believed by Professor Wilder in the case of the human subject to be one and the same dismembered muscle, are in the opossum actually one and the same; there is no division of their common plane, which extends unbroken from a long series of dorsal and cervical pleurapophysial elements, by numerous converging fascicles, to the occipital pleurapophysis. It is not, perhaps, going too far to suggest that these muscles may also be referable to the trunk series. Of the four muscles remaining after these eliminations, two connect the scapula with the diapophysis of the atlas alone, and two with the occiput and several spines of cervical and dorsal vertebræ. Thus it is seen that all the muscles of the scapular arch appear to grow out of the peculiar relations of this hæmal arch to its own and other vertebræ. While it would be premature and unwarrantable to assert that the scapular muscles are highly developed, differentiated and specialized components of the vertebral or trunk series, it cannot be denied that there are grounds upon which to base a belief that such may be the case. In

this event, in spite of their important teleological relations to the fore limb, they would not form, morphologically speaking, an integral part of the muscles of that member.

Be this as it may, it is certain that there are no muscles in the hind extremity to correspond to these of the fore. Admitting some principle of antero-posterior symmetry, of however extended or restricted application, this very fact, so far from invalidating such an admission, rather confirms a belief in the theory. If the scapular arch were firmly bound in its proper morphological position, as it is in most of the class of fishes, and as the pelvic is in the present instance, it is a fair logical induction that these muscles would be greatly reduced in number if they were not to wholly disappear. In view of these considerations it would seem unreasonable to expect, conformably to any law of antero-posterior symmetry, that the scapular muscles should be repeated in the pelvis.

We may allude, in this connection, to a theory that supposes the morphological representation of the scapular muscles in the pelvico-vertebral ligaments. Independently of what has just been adduced, what is known regarding the transmutation of contractile muscular, and inelastic fibrous, tissues, is sufficient to hold this presumption in abeyance.

The pelvic arch, unlike the scapular, is immoveably attached to vertebræ, in what is not known to be other than its true morphological situation. Its mode of union with the spine may practically be considered the same as that by which most other hæmal arches—notably the costal—are joined. Of the several trunk muscles going to or from the pelvis, only one gives intimation that it is a muscle of the posterior extremity, properly speaking, and this intimation is by no means satisfactory. The caudal muscles arising on or in the pelvis are palpably part and parcel of the vertebral series. The abdominal muscles likewise are as evidently of the nature of the intercostal series, and only incidentally, as it were, attached to the pelvis. The exception just alluded to is the psoas parvus, which has definite insertion into the horizontal ramus of the pubis. This muscle I do not attempt to homologize; nor, so far as I know, has its homology been made out. Its scapular homologue is wanting; did it exist it would naturally be looked for in somewhat the position of the subclavius. It is questionably a proper muscle of the hind limb.

Proceeding now from the hæmal arches themselves to the proximal segment of their "diverging appendages," we straightway meet with farther difficulty. Six muscles, collectively known as the "rotatores femoris," are found about the hip, proceeding from the pelvis to the thigh, that have no scapulo-humeral homologues, so far as known. They are the quadratus, pyriformis, two obturatores, and two gemelli; the last two of which, however, are rather accessories of the obturator internus than distinct muscles, leaving really only four. Of these, one is what Wilder would probably call a "long" muscle, as it extends beyond the ilium to the vertebral column. These muscles appear to be developed, teleologically, to meet a special indication, which in the shoulder is fulfilled by the mode of insertion of muscles homologous with the pelvic glutæi. I do not venture to surmise what may be the true morphological import and relations of these rotatores, nor to suggest that they may be glutæal dismemberments, although some features of at least one of them, the quadratus, might be adduced in favor of such view. The obturatores scarcely afford me basis for conjecture.

The latissimus has thus far resisted all attempts that have been made to bring it satisfactorily into line. It is the "long" direct flexor of the humerus. The femur has no such muscle, unless it is found in the psoas magnus; and to this view of the case there are

grave objections arising from the position and relations of the latter muscle. At the same time the psoas is not otherwise satisfactorily accounted for; at any rate, I cannot regard it as the "accessory short extensor" of the femur, nor see its homologue in the supraspinatus, as Professor Wilder has. Unless I misunderstand that writer's use of the terms, the psoas is the "direct long flexor" of the femur—just the opposite. For the rest, there is something to give color to the conjecture that the psoas and iliacus form one muscle, inasmuch as they have a common insertion, and similar function.

Few anatomists will be disposed to deny the homology of the subscapularis and iliacus; their position being identical, their relations nearly the same; and both having rotation as a prominent feature of their action. They both belong, furthermore, to the "short" flexor set, as "accessories."

There are three large muscles upon the outer surface of the scapular arch, all partly overlapping each other, all acting upon the proximal extremity of the humerus. They are, from before, backward,—deltoid, supraspinatus, infraspinatus. There are likewise three upon the outside of the pelvic arch, corresponding in position, relation, and virtually in function; they are, in reversed direction,—from behind, forward,—ecto-glutæus, meso-glutæus, ento-glutæus. These are readily acceptable as homologous; in fact, it is not easy to see how an opposite conclusion may be reached. In the case of the deltoid and ecto-glutæus, the correspondence extends to such an unusual degree as to be observable in the texture of the muscular fascicles. It is difficult to say to what set or sets of muscles—whether flexor or extensor, or long or short — these three muscles are morphologically reducible; the probability is, that they comprehend both. The glutæus maximus is certainly both long and short in having sacral and iliac portions; while the action of the three together, both at shoulder and hip, is so complex—and particularly in the cases of the spinati and two smaller glutæi—so varied in different animals, that they can hardly be said, in general terms, to have any specifically determinate mode of operation.

The teres major lies along the posterior border of the scapula, and is the short direct flexor of the humerus. At the hip there is a little muscle lying along the corresponding (anterior) border of the ilium, and morphologically the short direct flexor of the femur; although its diminutive size—in fact, its almost rudimentary condition—precludes belief that it is teleologically of much account. This is the muscle described (p. 125,) as ilio-femoralis; but which is undoubtedly the same as that described by Traill, Wilder and others in certain quadrumana, under the name of "scansorius." This seems to be the homologue of the teres major.

The teres minor is wanting in the opossum; were it present I should be at a loss to account for it. The glutæus minimus, to which Prof. Wilder compares it, has just been otherwise homologized. It is an inconstant muscle, and it may not be going too far to inquire whether it be really a morphological integer. The two rhomboidei, and the levator anguli scapulæ and serratus magnus of human anatomy are conclusively parts of each other, not integers of themselves; and similarly the teres minor may result from teleological modification of one of the two muscles between which it lies. If it be referable to the infra-spinatus, as seems likely, judging from its insertion, rather than to the teres major, the difficulty vanishes; for it is then correspondent to the glutæus minimus.

The way has grown smoother as we have advanced, until now, encountering the great extensor bundles upon the front of the femur and back of the humerus, it is perfectly

clear. The triceps of the thigh is the triceps of the arm; it comprehends both long and short extensors of the next segment. The rectus femoris is the scapular head of the triceps, and is the long direct extensor. The vastus externus and vastus internus are respectively the outer and inner humeral heads of the triceps, and are the short direct extensors.

The peculiar office of the human sartorius is but faintly or not at all foreshadowed in lower mammals. In man a flexor of both thigh and leg, in other mammals, as in the opossum, it appears in its true character as accessory long extensor of the leg and indirect flexor of the thigh. Its homologue in the anterior extremity is the *de facto* slip from the latissimus but *de jure* distinct muscle, called by Owen omo-anconeus, and by Duvernoy dorso-épitrochlien.

In the anterior extremity a muscle, ordinarily of moderate size, in this instance extremely small, proceeds from the hæmapophysis to the shaft of the proximal segment of the diverging appendage; it is the coraco-brachialis. Similarly, in the hind limb, a set of muscles, ordinarily of great size, and in this instance extremely large, proceeds from the same to the same morphological point; they are the three adductors—magnus, longus and brevis; and there can be little doubt that collectively they are the homologue of the coraco-brachialis. The tests of position and relation go far toward proving this. It matters nothing that the one has little size or power, and that the other is large and strong. This is a purely teleological modification; and so is, also, the mutual relation of the two, considered as flexors or extensors; for the office of these muscles is notoriously variable in different animals. But it so happens in the opossum, from the shape of the parts, that the "adductors" are really powerful extensors, and only slightly adductive; and that what feeble action the coraco-brachialis has, is also extensive and adductive in about equal parts. The objection, that here are three muscles in the thigh to one in the arm, has little morphological import; but rather, on the contrary, is a good illustration of teleological dismemberment of a muscle—just such a modification as it is in some other cases expedient or necessary to take for granted.

One of the largest muscles or sets of muscles of the anterior extremity has not yet been accounted for — I allude to the pectoral. Their identification probably hinges upon our determination of the relationships of the clavicle and coracoid to the pubis and ischium. If the clavicle and pubis are the hæmal spines, and correspondent, the foregoing identification of the adductors with the coraco-brachialis is apparently most rational; both these muscles coming from hæmapophyses to the shaft of the first segment of the appendages; and there is nothing left to represent the pectorales but the pectineus. This is the view taken by Prof. Wilder. If, however, the clavicle be homologous with the ischium, as Prof. Wyman holds, the inference seems just, that the coraco-brachialis is repeated in the pectineus, and that consequently the pectorales are to be found in the adductors. I presume there is little or no question that the pectorales and coraco-brachialis are to be looked for, if at all, in the pectineus and adductors together; but a more special determination is rendered difficult by a variety of conditions. In the particular instance of the opossum, for example, the pectineus is really neither pubic nor ischiatic, but arises from the marsupial bone; and part of the origins of the adductors is pubic—that of the magnus alone being essentially ischiatic.

The cubital flexor system, situated upon the front of the arm, consists essentially of an

outer, radial, "long" flexor, and an inner, ulnar, "short" flexor; one bending one of the two parallel bones of the second segment of the arm, the other the other; they are the "biceps" (flexor cubiti radialis) and the "brachialis anticus" (flexor cubiti ulnaris). Such appears to be the fundamental morphological condition of the cubital flexors, stripped of teleological modification; which latter, however, may be varied in degree if not in kind. In the opossum, for instance, the long flexor is bipedal instead of bicipital; its "long head" is deficient, or rather absorbed in the short or coracoid head, and one of its feet is implanted upon the ulna; but such conditions as these are of obviously little import in a morphological point of view. Now in the system of crural flexors upon the back of the thigh, the same general conditions are met with. There is an outer, fibular, "long" flexor, and an inner, tibial, set of flexors; the latter, however, subjected to a high degree of modification as compared with the corresponding flexor of the arm. Regarding the "biceps"—the flexor cruris fibularis—there is no difficulty; it is recognizable as the homologue of the muscle of the same name in the arm. Its femoral head, when existing, as in the case of man, etc., appears to be, so to speak, a teleological interpolation; in the opossum the muscle exists in what appears to be its normal condition; arising by a single head from the hæmapophysis to proceed to the outer side of the second segment, without attachment in its course to the first segment, of which it is still, as in other cases, the indirect short extensor. Some very suggestive corroborative evidence of its relationships to the cubital flexor has been already noticed at p. 127. The case is different with the internal or tibial flexors; their homology is not so evident. Aside from the fact that there are three such muscles instead of one (which of itself, however, would not constitute a valid objection to their reference to the brachialis anticus), they are not "short" but "long" flexors; they arise from the pelvic arch and not from the first segment of its appendage; and there is, moreover, in other animals, if not in the opossum, a muscle (the poplitæus) which is precisely the internal direct short flexor of the leg, arising from the femur and inserted into the tibia, and therefore in a teleological sense at least, the exact representative of the brachialis anticus, which Prof. Wilder considers it to be. But if the gracilis, semitendinosus and semi-membranosus arose together or individually from the femur instead of the pelvis, I presume that there would be no hesitation on the part of any in referring them collectively to the brachialis anticus; so that their origin may fairly be held as the only valid objection to such a view of their homology. The observed range of variation of origin of homologous muscles, however, does not seem to indicate that this is an extreme case, and other tests, as of position, relation, etc., tend to confirm the view that these muscles are really homologues of the brachialis anticus; more especially their unquestionable relations to the biceps cruris, the homology of which is so indisputable. If this view be not correct, it is certain that there is no muscle of the arm to which these important ones of the leg can be referred. I am of opinion, therefore, that the gracilis, semitendinosus and semimembranosus are the "short" direct tibial flexors, and consequently the homologues of the brachialis anticus, notwithstanding that the poplitæus appears to be such homologue.

The poplitæus, when present, could then only be regarded as an accessory flexor. Its reference to the pronator radii teres, to which it bears some superficial resemblance, could only be made upon the supposition of the homology of the radius with the tibia—a view which, it is scarcely necessary to repeat, I can not endorse. It is most probable that no

homologue of the pronator teres can be found in the leg; and the same may be said of the supinator brevis. These two muscles, antagonistic in their action, appear as highly specialized developments, in the face of particular conditions necessary to the function of the hand, and so far as known, are not developed in the posterior extremity, although they would be looked for, if anywhere, in such a pedimanous animal as the opossum. The homologue of the pronator quadratus, however, is present in the interosseus muscle of the leg; one having substantially the same position, relation and function.

The supinator longus has been variously interpreted. Its insertion, in the human subject, into the styloid process of the radius, makes it virtually a humero-cubital muscle; and Prof. Wilder regards it as an accessory short flexor of the forearm like the other supinator and the pronator, and finds its homologue in the femoral head of the biceps cruris. With him, I look upon its supinating action as purely secondary, recognizing only flexion and extension as the fundamental motions of the limbs; but I conceive the muscle to belong to the carpal set, and see in it a long, direct, radial extensor of the wrist (what would be a "flexor" in ordinary anatomical language), and consequently as only an indirect "short" flexor of the forearm. For this, as well as for reasons already given, I cannot see the femoral head of the biceps in this homologue. In the opossum it goes to the wrist, not to the end of the radius. Bringing the supinator longus into this connection, it results that we have upon the radial side of the forearm four carpal muscles; two extensors—supinator longus and "flexor" carpi radialis; and two flexors—"extensor" carpi radialis longior and brevior; the homologues of which four are to be sought for in fibular, or outside muscles acting on the tarsus.

Noticing the origins and insertions of the long supinator and radial "flexor" (extensor), we find that the former arises from the outer, and the latter from the inner side or condyle of the humerus, and that both are inserted at or near the outside bone of the proximal carpal row—the scaphoid. In the leg there are two large extensor muscles, whereof one arises from the outer, and the other from the inner, condyle of the femur; and both proceed to be inserted by separate tendons into an outer bone of the proximal tarsal series—the calcaneum. These two extensor muscles, the gastrocnemii, in the opossum instructively distinct from each other in origin, course and insertion, have precisely the same relations in the leg that the supinator longus and "flexor" carpi radialis hold in the forearm. If our osteological premises are correct—and there seems no good reason for doubting this—the gastrocnemius externus is the homologue of the supinator longus, and the gastrocnemius internus is the homologue of the "flexor" (extensor) carpi radialis.

Looking now to the other two of the four radio-carpal muscles, we find that the "extensor" (flexor) carpi radialis longior and brevior arise together or contiguously from the outer condyle, lie along the radial side of the fore arm, and are inserted by distinct tendons into two contiguous parallel metacarpal bones—the second and third, counting from radial to ulnar side. Similarly, there are in the leg two fibular tarsal muscles, arising, if not from the outer femoral condyle itself, at least from the corresponding side of the leg, lying along the fibula, passing behind the external malleolus (= head of the radius) to gain the back and outer side of the tarsus, and finally proceed to a metatarsal insertion; they are the two larger peronei. The insertion of these muscles, however, does not, further than in being metatarsal, correspond to that of the wrist muscles just mentioned, for instead of going to contiguous second and third metatarsals, counting from without inward, one stops

at the first (outer or "fifth" of ordinary anatomical language), and the other is carried quite across the foot to the fifth (inner or "first"). But this seems to be a result of special teleological modification, rather than a morphological disparity, and should not weigh unduly against numerous other evidences that the peroneus longus is the homologue of the "extensor" (flexor) carpi radialis longior, and the peroneus brevis the homologue of the "extensor" (flexor) carpi radialis brevior. Position, relation, and even function attest the correctness of this view. The peronei, like the so-called radial wrist "extensors," are really and essentially flexors; and in the ordinary position of the foot, at right angles with the leg, have actually this action, though when the foot is so strongly extended as to be brought in a straight line with the leg, they may act as extensors. This difference results solely from the mode of confinement of the tendons at the malleolus, and is purely teleological; a similar variance in the action of the radial wrist "extensors" would occur, were the tendons of the latter slipped around the head of the radius. The view here taken of these muscles is further supported upon a principle of exclusion, so to speak; the only other muscles to which the peronei could be referred being satisfactorily homologized without reference to the peronei.

The inner, or ulnar and tibial, muscles next come to be examined. There are two such muscles — a flexor and an extensor — in each limb. In the fore, the "extensor" (flexor) carpi ulnaris proceeds along the inner side and back of the forearm and wrist, to the base of the inner (fifth) metacarpal; it flexes the wrist, or draws it backward. In the hind, the tibialis anticus (flexor tarsi tibialis, as it has been well named), has entirely correspondent position and relations; passing over the inner side of the ankle and instep to the internal cuneiform bone, at the base of the inner (fifth — "first" of usual language) metatarsal, it flexes the foot, or draws it forward. Similarly, upon the other side of the fore limb, the "flexor" (extensor) carpi ulnaris proceeds along the inner side and front of the wrist, to the pisiform, extending the wrist or drawing it forward; and in the hind limb the tibialis posticus (extensor tarsi tibialis) has the same relations and functions, and virtually, if not actually, the same insertion, viz.: the navicular, which is the innermost of the proximal row, here taking the place of the pisiform, which has no tarsal homologue.

I find the "peroneus tertius" to be one of the most puzzling muscles of the limbs, and believe that others have met with similar difficulty in the attempt to determine its homology. In the first place, it is not easy to trace it from one animal to another, and so determine its general homology; for it is an inconstant muscle, wanting in many, if not the majority, of mammals, and when found it is variable in its position, relation and function. In man, for instance, the muscle called peroneus tertius is, when present, an insignificant one, looking like a detachment from the long digital extensor, and proceeding to the base of the outer metatarsal. In the opossum the muscle I call, and believe to be, peroneus tertius, is large and important, and the proper long extensor of the little toe; but I am not *fully* satisfied that this digital extensor is the peroneus tertius (see remarks, foot note, anteà, p. 130). Still this is the best identification I can make; any other involves greater objections. Thus, for example, if this little toe extensor of the opossum be not the third peroneus, it is an extra muscle, that has no correspondent in the hand, nor in many other mammals; the extensor minimi digiti of the fore limb being quite another thing. Again, upon the same supposition, we should be forced to view the muscle I call extensor digitorum brevis, as the peroneus tertius, in order to find the latter at all; a view against which,

it need not be said, there are grave objections. These, and other considerations, lead me to see a peroneus tertius in this extensor of the little toe; and I base my search for its homologue in the fore limb upon this assumption. I cannot see the grounds of Prof. Wilder's reference of the peroneus tertius to the "extensor" (flexor) carpi radialis brevior, which seems to be naturally accounted for otherwise as I have just endeavored to show; and this view, moreover, necessitates his reference of the peroneus longus to the "flexor" (extensor) carpi radialis. There seem to be but two muscles upon the back of the hand to which the peroneus tertius can reasonably be referred; one is the extensor pollicis et indicis, the other the extensor metacarpi pollicis. For reasons given below, I identify the former of these with the extensor brevis digitorum pedis, and am consequently obliged to find the peroneus tertius in the extensor of the pollical metacarpal. It may be further urged, in support of this view, that these two muscles belong to corresponding groups, radial and fibular; occupy nearly similar positions upon corresponding sides of the hand and foot; and operate exclusively upon corresponding digits. Whatever objections may be brought against this view—and it is not denied that there are such—appear to be over balanced by evidence in its favor.

The plantaris is obviously homologous with the palmaris longus. A palmaris brevis is scarcely if at all demonstrable in the opossum; it probably has no homologue upon the sole of the foot.

Both fingers and toes are flexed by two sets of muscles, called in the arm "deep" and "superficial," and in the leg, "long" and "short." The short flexors of the toes, in the human subject confined to the sole, are in the opossum carried up the leg, and arise from, and lie upon, the conjoined tendon of the long flexor. The muscular parts of the superficial and deep flexors of the fingers are much blended. But however the origins and upper parts of these muscles may vary, in either arm or leg, or both, they preserve with remarkable constancy certain characteristics at their distal extremities and insertions. These are:—the tendons of the deep flexor of the fingers, and of the long flexor of the toes, are large and stout, are accompanied by accessory muscles (lumbricales) and proceed *through* the tendons of the other set to be inserted into ungual or distal phalanges; while the superficial flexor of the fingers, and the short flexor of the toes, are smaller and slender, unaccompanied by accessories, and proceed, by splitting, upon either side of the tendons of the other set, to be inserted into middle, or second phalanges. Such definite indications as these would seem to go so far toward establishing the homology of the deep with the long, and of the superficial with the short sets of flexors, that opposing evidence, to be valid, would have to be of the strongest kind.

While the correspondence of the deep digital flexor system of the hand with that of the foot is thus obvious and unquestionable, yet on carrying it out in details we meet with individual correlations as interesting as they are unexpected. For the four-tendoned long flexor of the toes is not, as would be thought at first glance, the homotype of the four-tendoned long flexor of the fingers, but of the single long flexor of the thumb, which in the opossum remains undeveloped; and similarly, the single long flexor of the great toe in the opossum, developed as to its muscular part, but abortive as to its tendinous part, is the homotype of the four-tendoned flexor of the fingers. This proposition is susceptible of pretty conclusive argument. In the arm the profound digital flexors consist essentially of a single muscle with five tendons, one for each digit; and when this is differentiated into

two, the inner (ulnar) part of the muscle has four of the tendons for the four fingers, and the outer (radial) part has one tendon for the thumb. Likewise, in the leg, the originally five-tendoned flexor is differentiated into two muscles, an inner (tibial) muscle with one tendon for the great toe, and an outer (fibular) muscle with four tendons for the other toes. Now bearing in mind the relative positions of each of these special dismemberments, and remembering that our correspondences are to be drawn according to position and relation, not according to size, number of tendons, etc., it is necessary to conclude that the two *inner* (ulnar and tibial) moieties are homologous with each other, and that the two outer (radial and fibular) moieties are likewise mutually correlated. That is to say, the flexor longus proprius pollicis of the foot is the homotype of the flexor profundus digitorum of the hand; and the flexor longus digitorum of the foot is the homotype of the flexor longus proprius pollicis of the hand. In the opossum there is no actual long flexor of the thumb, unless, as is probably the case, the abortive fasciculus described as lying on the substance of the common deep flexor be that muscle; and similarly, the long flexor of the great toe, though distinct as to its muscular part, really sends no tendon to the toe; but this constitutes no valid objection whatever.

In further illustration of the homotypy of the long, deep, digital flexors, the reader is referred to my article (No. VIII) in the *Medical Record*, as above cited, where the curious special condition that occurs in man is especially treated of. These flexors are so notoriously inconstant in their amount of development, their number of tendons, and the particular digits that each serves, that confusion has arisen, which would be happily obviated by a little more precise nomenclature. Ignoring number of tendons, and the digits they serve, the following names are proposed: In the arm, flexor digitorum *ulnaris* for the inner moiety, and flexor digitorum *radialis* for the outer moiety; in the leg, flexor digitorum *tibialis* for the inner moiety, and flexor digitorum *fibularis* for the outer moiety. It is probable that similar considerations are applicable in special determinations of the superficial and short flexor systems, if not also the sets of digital extensors; but at present I am not prepared to follow up the subject.

Like the flexor, the extensor system consists essentially of two sets of muscles, which may be denominated the "long" and "short" in both limbs. The former is the more constant and important; it gives off, on the back of both hand and foot, four tendons, which supply the four fingers and the four lesser toes, the thumb and great toe wanting tendons, as in the instance of the flexor set. The same idea of a typical extensor muscle with five tendons—one to each digit—is more perfectly carried out than in the analogous case of the flexors. For here we have, not merely teleologically correspondent, but morphologically homologous muscles liberated on the same (inner) side of the hand and foot; they are the extensor proprius minimi digiti of the hand, and the extensor longus proprius pollicis of the foot. This identification of these two last named muscles is indisputable, and is not affected, apparently, by the question whether they really are dismemberments of the common extensor.

The extensors of the other set, the "short" or accessory, are more obscure, and their homologies more difficult to determine. In man the short extensor lies wholly upon the dorsum of the foot, and supplies the same digits that receive tendons from the long extensor; but in the opossum it is carried up the leg, and its tendons descend behind the external malleolus. In man, we have as the only muscles of the hand to correspond to this of the

foot, the extensor indicis and extensors of the pollical internodes; in the opossum, one of the latter is deficient, and the other joins the extensor indicis, forming an extensor of the thumb and forefinger together. Whatever may be said upon the opposite, I have no alternative but to view these combined extensors as homologous with those of the foot just mentioned.

As will have been gathered from a former part of this memoir, the short palmar muscles of the thumb and little finger are very similar; and so also, are those of the great and little toe. They appear to consist essentially of a short flexor, an adductor, and an abductor in each instance; either of which, however, may be somewhat modified; as, for example, divided into two more or less distinct portions. The curious, oblique short flexor of the great toe, elsewhere particularly described, does not appear to belong to the group with which it is associated, but rather to be a specialized part of the long flexor system. With this exception, there appears to be little difficulty in homologizing the short palmar and plantar muscles. Bearing in mind the morphology of the digits, the short muscles of the little toe are to be referred to the thenar muscles of the hand, and those of the great toe to the hypothenar.

The lumbricales and interossei of hand and foot are obviously homologous. In the case of the former, identification of the individual tendons of the deep and long flexors determines them, each for each. Both sets of interossei are as easily determined, individually, by the correspondences of the digits with which they are in relation.

The following provisional table exhibits the homologies of the muscles of the fore and hind extremities, according to the identifications that I have endeavored to establish in the present study. However novel any of the correspondences may appear at first glance, it is hoped that they may not be hastily set aside, nor condemned without fair regard to the reasoning by which they have been reached. I should add that Part III. of the present memoir is merely an abridgement of an argument, originally penned some years since, and which in the interim has appeared in the New York *Medical Record*, as above cited, in its application to the muscles of the human subject; and that therefore it should be regarded as simply corroborative of the articles in the *Record*, and examined in connection with the latter. Some additional investigations of like character were made in a dissection of the Ornithorhynchus, and published in the last volume of the Proceedings of the Essex Institute.

ANTERIOR EXTREMITY.

Cleido-mastoideus.
Subclavius.
Omo-hyoideus.
Trapezius.
Rhomboideus.
Atlanto-acromialis.
Atlanto-scapularis.
Levator anguli scapulæ.
Serratus magnus.
} (Qu.: muscles of the fore limb?)

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Latissimus dorsi.
———?
} (long, direct ? flexor.)

Subscapularis.
Deltoideus.
Supraspinatus.
Infraspinatus.
Teres major.
Triceps (scapular head).
Triceps (inner humeral head).
Triceps (outer humeral head).
Omo-anconeus (Dorso-epitrochlearis).
Pectoralis.
Coraco-brachialis.
Biceps (Flexor cubiti radialis).

Brachialis anticus (Flexor cubiti ulnaris).

———

Pronator radii quadratus.
Pronator radii teres.
Supinator brevis.
Supinator longus (a radial wrist extensor).
Extensor[1] carpi radialis.
Flexor[2] carpi radialis longior.
Flexor[2] carpi radialis brevior.
Flexor[2] carpi ulnaris.
Extensor[1] carpi ulnaris.
Extensor ossis metacarpi pollicis.
Palmaris longus.
Flexor digitorum profundus.
Flexor longus pollicis manûs (here rudimentary).
Flexor digitorum sublimis.
Extensor digitorum communis.
Extensor indicis et pollicis.
Extensor minimi digiti.
Musculi breves pollicis (thenar).
Musculi breves minimi digiti (hypothenar).
Lumbricales.
Interossei anconei.
Interossei palmares.

POSTERIOR EXTREMITY.

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Psoas parvus.
Pyriformis.
Quadratus femoris.
Obturator externus.
Obturator internus.
Gemelli.
} ("Rotatores femoris.")

———?
Psoas magnus.
} (long ? direct flexor.)

Iliacus.
Glutæus maximus.
Glutæus medius.
Glutæus minimus.
Ilio-femoralis.
Triceps (rectus femoris).
Triceps (vastus internus).
Triceps (vastus externus).
Sartorius.
Pectinæus.
Adductores (three).
Biceps (Flexor cruris fibularis).
Gracilis.
Semitendinosus.
Semimembranosus.
} Flexores cruris tibiales.

Poplitæus (here wanting).
Interosseus cruris (Pronator fibulæ quadratus).
———?
———?

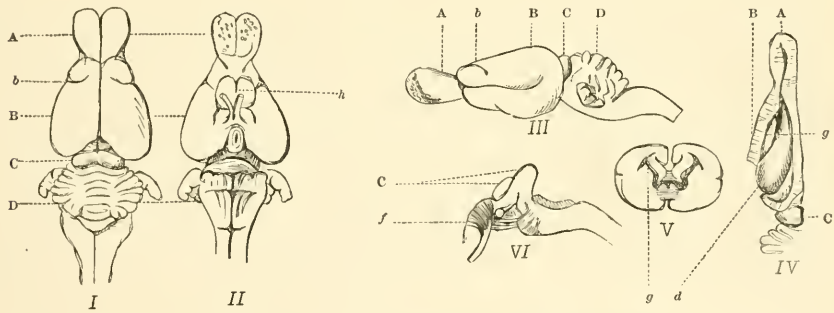
Gastrocnemius externus.
Gastrocnemius internus.
Peroneus longus (Flexor tarsi fibularis longior).
Peroneus brevis (Flexor tarsi fibularis brevior).
Tibialis anticus (Flexor tarsi tibialis).
Tibialis posticus (Extensor tarsi tibialis).
Peroneus tertius.
Plantaris.
Flexor longus pollicis pedis (here abortive).
Flexor digitorum longus.
Flexor digitorum brevis.
Extensor digitorum longus.
Extensor digitorum brevis.
Extensor longus proprius pollicis.
Musculi breves minimi digiti.
Musculi breves pollicis pedis.
Lumbricales.
Interossei rotulares.
Interossei plantares.

[1] "Flexor" of ordinary language. [2] "Extensor" of ordinary language.

Description of the Brain of the Opossum. By Jeffries Wyman, M.D.

The most striking feature of the brain of the opossum, when compared with that of placental mammals, is the large size of the olfactory lobes, and their position in front of the cerebral hemispheres, the shortness of these last, the considerable interval between them and the cerebellum, and the consequent exposure of the optic lobes. When the skull is viewed as a whole, the cranial portion, which envelopes the brain, is remarkable for its diminutive size, and in this particular reminds one of the skull of a reptile.

Three specimens of adult brain which had been hardened in alcohol, and were therefore somewhat smaller than natural, displaced respectively 4.4, 4.4 and 4.5 cub. cent. of water, and one of them measured 40 mm. in length and 20 mm. in breadth.



I, upper, II, under, and III, side view of brain. IV, horizontal section, showing the ventricle of the olfactory lobe, corpus striatum, hippocampus, and the smaller convolution, also the optic lobes and a part of the cerebellum. V, transverse section behind the anterior commissure. VI, optic lobes, optic thalami and optic nerve.

A, Olfactory lobes. B, Cerebral lobes, or nates and testes. C, Optic lobes. D, Cerebellum. *b*, transverse furrow; *d*, large internal convolution, or hippocampus; *f*, optic thalamus and optic nerve; *g*, corpus striatum; *h*, bulging of the surface surrounded by well marked furrows.

Olfactory lobes.—Seen from above, these form two egg-shaped masses (figs. I, II, III, IV, A), flattened against each other, somewhat higher than broad, from 9 to 10 mm. long, from 5 to 6 mm. high, and merging without any very distinct line of separation in the lower half of the fore part of the cerebral lobes. Beneath they are from 12 to 13 mm. in length, underlap the cerebral lobes and here as well as on the sides are distinctly circumscribed. Each lobe is hollow, and if a cross vertical section is made each ventricle is seen as a nearly vertical slit inclined slightly outwards. It is largest in the middle of the lobe, contracts toward either end, but as it approaches the cerebral lobe connects with the ventricle of this, as seen in the horizontal section fig. IV, by an almost capillary opening.

The ventricle of the olfactory lobes nowhere communicates with the surface as, undoubtedly through the fault of the engraver, the figures of Owen seem to indicate.

Cerebral lobes.—The two together are somewhat pear shaped and considerably flattened vertically. (Figs. I, IV, B.) They separate from each other behind, leaving a triangular space in which the optic lobes are partly exposed. The surface is marked with very distinct vascular impressions which branch off from two principal trunks, the smaller one beginning near the optic chiasma and extending forwards and upwards, and the larger extending horizontally along nearly the whole length of the side of the lobe.

After the membranes are stripped off two infoldings or *convolutions* of the cortical substance are seen. The first (fig. III) corresponds in position with the larger vessel referred to above, and its sulcus is closed by this vessel superficially. Beginning just over the roots of the olfactory lobes it extends backwards in a curved line to the hinder part of the hemispheres. It divides each hemisphere on the surface into an upper and lower portion, the latter as already stated being continuous with the olfactory lobes. The second infolding is quite small and crosses the upper and fore part of each lobe (figs. I, III, *b*), forms a crescentic furrow, extends from near the middle line above, on to the sides and ends near the sulcus just described, but not connecting with it. On either side of the optic chiasma an oval bulging of the surface is seen (fig. II, *h*), having the appearance of a convolution and surrounded by a deep groove.

If a longitudinal section of the brain is made and the under part of the cerebral hemisphere lifted from its place, two additional infoldings of the surface are brought into view; the larger of them, beginning near the optic chiasma and winding around the inner surface of the hemisphere, is there seen on its vertical portion and ends near the union of the hemisphere with the olfactory lobe. The second infolding is quite small and is found just above the hinder part of the preceding. If the thin upper walls of the cerebral hemispheres are removed, two convex foldings, corresponding with the infoldings just described, will be seen, forming the oblique floor of the ventricle. The smaller and hindermost of these (fig. IV), though a distinct and constant part, does not appear to have been noticed in the descriptions of the brain of the opossum, but the larger (*d*) is known as the *hippocampus*. This last is of great size and fills nearly the whole cavity of the ventricle, and may be compared in shape to an ox horn, its point being directed forwards. Behind, it rests upon the nates and optic thalami, and in front it embraces the *corpus striatum* (*g*) in its hollow.

Commissures.—These are represented in the brain of the opossum, chiefly by the corpus callosum, fornix and anterior commissure. Owen, in his early and most valuable investigations of the brain of Marsupials and Monotremes, while he recognizes the existence of a "rudimental commencement of the corpus callosum," in his zoological conclusions and descriptions, leaves it out of the account as if it were wholly wanting, and assumes that the absence of it is an especial characteristic by which the Placental and Implacental Mammals are distinguished from each other, and this view has been largely accepted by zoologists. Leuret, Blainville, Pappenheim and other continental anatomists have expressed their dissent to this view, and Mr. Flower, by a series of comparative dissections, has shown the actual presence but gradual reduction of the corpus callosum in Placental Mammals, and its still further reduction in Marsupials and Monotremes. Throughout the whole of both series, this part retains its essential features and is simply reduced in size by

being shortened from behind forwards so that its hinder edge, instead of being over the tubercula quadrigemina as in man, is just above the anterior commissure. Owen, however, maintains that the corpus callosum in Implacentals has a morphological value only and not a zoological, and is no more the corpus callosum of Placentals than a "bract" is a "leaf." By a parity of reasoning a Batrachian might be described as destitute of a cerebellum.

When the hemispheres of the opossum are separated from each other, the corpus callosum is brought into view at the fore part of the longitudinal fissure, just above and resting upon the fore part of the optic thalami, consisting of a transverse, nearly cylindrical band, somewhat compressed from above downwards, and attached to the inner walls of the two adjoining hemispheres. It consists of white fibres which enter the substance of the hemisphere just below the hippocampal sulcus, where the fibres radiate in a fan-shaped manner, but chiefly backwards, and are spread out over the convex surface of the hippocampus and end in the cerebral walls along the angle where these are reflected upwards in the great longitudinal fissure. The remainder of the fibres are directed forwards and downwards and were traced to the fore part of the cerebral lobe. It will be seen, therefore, that the connections established by means of the corpus callosum are quite extensive.

It is in the reduction of the corpus callosum to its diminutive proportions that the brain of the Marsupials and Monotremes most closely resembles that of the oviparous classes, in which last no trace of it has thus far been recognized. In all other respects, however, it maintains its mammalian features, and shows nothing deviating from these to the same extent as do the organs of generation, from the usual structure of these parts in ordinary or placental mammals.

The parts which are supposed to represent the *fornix* in the opossum, though quite diminutive, are traced without much difficulty. They consist of two fibrous bands slightly separated from each other, which at one end are connected with the foremost part of the optic thalami, thence pass upwards over the "hard" or anterior commissure, resting closely on its surface and at the same place becoming attached to and apparently interchanging fibres with it, and descending in front of it are lost in the cerebral substance adjoining. Some of the fibres make a nearly complete circuit of the commissure. The portions of the fornix which lie in front of, and behind, the anterior commissure, correspond with the so called "pillars"; and if we could suppose the corpus callosum gradually enlarged and its hinder edge pushed backwards carrying the attachment of the fornix with it, these pillars would be gradually lengthened so as assume the proportions they have in Placental Mammals, those in front being the ones which Huxley calls precommissural.

In the median longitudinal section, the divided *great commissure* and the corpus callosum are represented by two oval sections, the long axes of which incline towards each other from opposite directions, and if prolonged would meet in front of them. The section of the *great commissure* is nearly twice as large as the other, and has only the pillars of the fornix interposed between it and the optic thalamus. Its fibres are easily traced, radiating into the adjoining parts until they are lost in the fore part of the cerebral lobes and the corpora striata.

The *Optic lobes* (tubercula quadrigemina) taken together, form a wedge-shaped mass inserted between the cerebellum and the optic thalami, and in general resemble the same parts in the rat. The *testes* issue vertically from the fourth ventricle, and have on their hinder face a deep concavity which the middle lobe of the cerebellum fills. Above they

are divided into two oval masses, become much thicker below, and as they approach the crura, the lowest part projecting forwards. The *nates* are much smaller, are also divided into two lobes, have a flattened oval shape, and rest upon the more advanced portion of the testes to which they seem only appendages.

The optic thalami, nates and testes might be described superficially as a single mass of cerebral substance divided by grooves into three pairs of lobes, the groove between the nates becoming suddenly deeper at its foremost point so that its continuation separates the optic thalami from each other, and thus forms the third ventricle. On each side of the entrance to the third ventricle is a raised lip on which the peduncles of the pineal body rest. The connections of the thalami with the fornix have already been described.

The passage from the third to the fourth ventricle becomes suddenly enlarged, under the optic lobes, and if a transverse section be made through these it assumes the dimensions of a ventricle under the testes.

The optic tracts reaching the sides of the optic thalami, spread out in a fan-shaped manner covering the whole surface. A few fibres were traced into the nates and into a small, flattened, circular body, which occupies the place of a corpus geniculatum.

The *Cerebellum* consists of a middle lobe which, seen from behind, has nine convolutions, some of which do not extend beyond its borders; of two lateral lobes, each with six or seven convolutions, the upper and lower of which extend across the median line; and of the slender appendages on each lateral lobe usually seen in Marsupials, each of which has three or four minute convolutions. The middle lobe forms a continuous ridge around nearly the whole circumference of the cerebellum, being interrupted only on its hinder edge over the fourth ventricle. Besides the sulci seen on the general surface, there are two somewhat remarkable ones, which can only be seen by examining the anterior or that face of the organ which is in contact with the vertical portion of the testes. One of these detaches the middle lobe in front, as far as the base of the cerebellum, from the posterior, middle and lateral lobes; the entrance to it is from near the top of the cerebellum, and its direction, as seen in a longitudinal section, is from above downwards and backwards. A second and smaller one is seen below this and has a direction parallel to it.

IV. The Development of Limulus Polyphemus. By A. S. Packard, Jr., M.D.

Read November 16, 1870.[1]

THE earliest information we have regarding the early history of the King Crab, is a note by Milne Edwards,[2] who examined the "eggs of Limulus containing the young ready to hatch, and found that in this stage of their development, they offered in the anterior portion of their body a mode of structure but little different from that which exists in the adult, while the abdominal portion of the body carries but three pairs of appendages, and the long styliform tail, so remarkable in the adult, does not yet exist; the form of the abdominal portion is equally different at this period."

The next observations were made in the years 1869 and 1870, by Rev. Samuel Lockwood, Ph.D., and communicated by him to the "American Naturalist" (IV, p. 257, 1870). The more important facts discovered by him are incorporated in this paper. Mr. Lockwood was unable to make microscopic observations on the egg, and kindly forwarded me from Raritan Bay, New Jersey, where the animal is more abundant than in New England, numerous specimens of the freshly laid eggs, in the springs of 1870 and 1871; and it is to his ardor and enthusiasm in searching out the "nests" of the King Crab at the favorable moment, by no means an easy task, that we are indebted for the means of obtaining a quite complete history of the extraordinary mode of development of this interesting crustacean.

I should also say that it was owing to the earnest solicitation of my friend, Dr. Anton Dohrn of Jena, that I was first impelled to seek for the eggs of this crustacean, and send him a series for study. His results, published in the "Jenaische Zeitschrift, 1871," had not reached me at the time of going to press with this article.

Previous to Mr. Lockwood's discovery of the larva of Limulus, Mr. Alexander Agassiz had, as he informs me, captured with a net the larva of this species swimming free on the surface of the ocean, three miles from the shore of Naushon Island, Buzzard's Bay, and made a drawing of the specimen, but did not mention the fact in print.

The eggs were laid on the 16th of May. Mr. Lockwood states that the female "spawns at or near the new and full moon, in the months of May, June and July, embracing the time of the extra high tides, which depend so greatly on the lunar influence. They come up at a great high tide, advancing on the bottom until they reach a suitable spot near to, but within, the extreme line of this great tide. Three definite advantages are in this way secured. First, the spawning is performed under water, or without undue exposure; second, the line of the average high tide is thus selected; and third, a short exposure to

[1] Since this paper was offered for publication, I have been able, through a delay in the printing, to make during the summer of 1871 a new series of observations, so that this article has been materially changed since it was originally prepared for publication.

[2] Recherches relatives au développement des Limules in Soc. Philomatique Extr. Proc. verb. 1838, p. 125-126.—l'Institut, VI. no. 258, 1838, p. 397. I have not been able to see these journals, and take the above account from J. Van der Hoeven's "Recherches sur l'Histoire Naturelle et l'Anatomie des Limules." Leyde, 1838.

the daily low tides is thus secured, by which the proper exposure of the spawning spot to the development-accelerating heat of the direct rays of the sun is obtained." "The female excavates a depression in the sand, drops her spawn into it, upon which the male emits the fecundating fluid, and the nest is at once deserted, the parents returning seaward with the retreating tide. By the action of the water the eggs are immediately covered up with sand; though if the wind be unpropitious, large numbers are often washed up and cast in windrows on the beach, and soon devoured by the many hungry beings of bird, fish, and mollusca kind that always abound." In the harbor of Beaufort, North Carolina, in company with Dr. Elliott Coues, I have observed the Limulus in pairs buried in the sand at about half tide, and in digging down invariably found the male above the female. On opening the female, ripe eggs were found in several instances during the middle of May.

The freshly laid eggs measure .07 of an inch in diameter, and are green. While most of them are spherical, others are oblong and a little flattened. In the ovary they are of various hues of green and pink, just previous to oviposition, while the small, immature ones are white. The yolk is dense, homogeneous and sticky, the whole mass on being squeezed out not separating into single cells, which float off in the water of the glass, as in most crustacea. The yolk granules are very small and not easily seen, unless the egg is crushed. The chorion is quite opake, very tough and dense. When ruptured, the torn edges show that it is composed of five or six irregular layers, varying in thickness, of a structureless membrane.

The spermatozoa (Pl. III, fig. 1,) are broad, oval, sometimes contracted before the anterior end, and posteriorly suddenly terminating in a filament about four times as long as the body of the cell. The seminal fluid is thin, whitish, and oozes out of the two papillæ situated on the under side of the first pair of abdominal feet. The vas deferens may be traced for over an inch towards the middle of the cephalothorax, but I have not farther traced it, nor has Van der Hoeven,[1] who has made the most careful dissection of Limulus that has yet been published.

The ovaries, opening by two oviducts ending in two external papillæ situated on the under side of the first pair of abdominal feet, have been described by Van der Hoeven, but more fully by Gegenbaur.[2] The oviducts pass directly upwards to the roof of the carapace, the ovaries spreading over the entire dome of the carapace just above the liver, the subdivisions or tubes of the ovaries extending to the extreme anterior edge of the carapace, and also passing back into the abdomen. The ovarian tubes are much alike, eggs of all stages of growth, from those but little larger than the original epithelial cells, to others just ready to pass into the oviduct, being intermingled along the tube. The ripe eggs of a large female would nearly fill a half pint vessel. Just previous to oviposition the oviducts are crowded with eggs, which can be squeezed out on slight pressure. On examining a male removed from its mate, I found that at the same time the seminal fluid of the male flows from the papillæ on the slightest pressure. There is probably no union of the sexes, the male ejecting his milt while burrowing in the sand attached to his partner by his claws.

Formation of the Egg. The smaller ovarian tubes consist of irregular layers of epithelial cells (Pl. III, fig. 2, *a*) irregular in form, though when crowded becoming more or less polyhedral, and provided with a distinct nucleus. Away from the edge of the tube the

[1] Recherches sur l'Histoire Naturelle et l'Anatomie des Limules. Par J. Van der Hoeven. Leyde, 1838.

[2] Anatomische Untersuchung eines Limulus, mit besondere Berücksichtigung der Gewebe. Abhandlungen der Nat. Gesellschaft zu Halle, Bd. 4, 1858, p. 229.

cells become indefinite in form, the nuclei disappear, and a stroma is formed, probably from the breaking down of these cells. From these epithelial cells arise the eggs (fig. 2), which thus originate from what cannot be optically separated from true epithelial cells, as observed by Gegenbaur. But along some of the tubes runs a sort of fold or ruffle, consisting of clear, non-nucleated cells (unless the nuclei were concealed by the overlapping cells), which project out from the edge of the fold (fig. 2, *b*). These also are apparently destined to become transformed into germinative vesicles, and subsequently eggs. They are elongated, crowded together, clear, pellucid, with a few molecules at the base of the cell. They pass gradually into the ordinary epithelial cells, which are smaller than those about the base of the fully formed cell-egg (fig. 2), and are entirely filled with molecules. Near these cells (fig. 2, *b*) were larger ones (fig. 2, *c*) easily detached from the stroma, spherical, and filled with molecules, but with a clear nucleolus. On becoming larger the nucleolus is filled with molecules, as at fig. 2, *d*, which are much darker than the molecules in the other part of the cell. Up to this time the contents of the cell-egg consist of protoplasm alone. The stage represented by fig. 2 is signalized by the formation of a layer of protoplasm (fig. 2, *pl*) around the germinative vesicle, and afterwards by the appearance of the fat or yolk granules, or deutoplasm. Less perfectly formed yolk granules are seen in the nucleus of the cell-egg. In another cell-egg farther advanced (fig. 3), the nucleus is more distinct, that portion of the wall of the egg situated within the pedicel being more readily seen than before. (Its distinctness in fig. 2 is exaggerated in the plate.) The molecules of the nucleolus are glistening or refractive bodies, and form a clearly defined, central mass, leaving the periphery clear.

The yolk granules are still clearer in other specimens (fig. 4), and in still others the cell-egg becomes more easily detached, and the yolk granules have increased in size, until, as in fig. 5, one or two are seen to be as large as the germinative vesicle. After this, the principal changes in the egg are the multiplication of the yolk granules, and the thickening of the egg membrane itself to form the thick, dense chorion. No yolk skin was observed, neither any micropyle.[1]

Formation of the Blastoderm. The eggs received during the second season had been laid several days, at least three or four, and the mode of formation of the blastoderm could not be seen. In endeavoring, therefore, to artificially impregnate the eggs of Limulus, the following appearance was observed. Six hours after the operation the surface of the yolk was seen to be covered with little balls of yolk cells projecting out, with deep spaces between them; the masses of cells being round, and not crowding on each other. I could not see whether these masses enclosed nuclei, owing to the opacity of the yolk. In twenty hours after the operation, the eggs, under a power of thirty diameters, were seen to be smooth again, and the surface covered with a layer of very indistinct pale cells (fig. 6,

[1] Gegenbaur remarks that he detected no yolk-skin (dotterhaut); and besides the cuticula of the egg-cell itself, in the egg in the stage observed by him at least, no special membrane traceable to a cellular membrane was observed, so that here occurs a case where cells at an earlier stage are provided with a membrane (such as covers the epithelial cells of the tubes of the ovary), which afterwards disappears (through resorption?) and then goes back to a lower stage of development. Indeed the cell undergoing this transformation acquires a new significance; it becomes an egg.

In the eggs loosened from their pedicels the scar thus formed appears like a micropylar opening. But in ripe eggs this opening becomes closed before the egg is laid. His observations were made on what he regarded *Limulus moluccanus*, though it came from the Antilles, and he thinks it could not be *L. Polyphemus*. I am not aware, however, that any other species than *L. Polyphemus* inhabits the West Indies. I have found it frequently at Key West, Florida, and find that it does not differ from specimens from Beaufort, N. C., Massachusetts, and Maine.

slightly enlarged) with small nuclei, dark in color, being seen with reflected light. They were round, or irregularly hexagonal when crowded together (fig. 6, *a*, enlarged 130 diameters). The interspaces were dark, of the same color as the nuclei, and appeared as if forming a fine net work covering the egg. They were difficult to detect, owing to the great opacity of the egg, but could be seen under a strong reflected light. In two days after the fertilization of the eggs, this layer of nucleated cells disappeared.

The surface of the yolk then became covered with rounded masses, becoming somewhat hexagonal when crowded, and made up of yolk granules. This balled appearance was observed a few days earlier in many of the eggs received from Mr. Lockwood, and can be easily seen with the naked eye. These balls soon disappeared and the surface of the egg became smooth again, and then the eggs presented the appearance noticed in the egg received from New Jersey, described below and figured on Pl. III, fig. 6, *b*, and 7. After a few days the surface of the yolk became again as seen in the naturally impregnated eggs just before the appearance of the germ, the transparent cells of the blastoderm being readily seen with a Tolles triplet.

While writing in my notes the preceding paragraph, an egg in which the blastodermic cells were distinctly developed, appearing like Claparède's[1] figure 1 (my fig. 6), went through under my eyes the following change alluded to above. The original blastoderm cells disappeared from view, and the surface of the yolk was suddenly covered with white masses of different shapes, but more or less angular. They seemed in the space of a few minutes (not more than five or ten) to start out into view and suddenly become very distinct. They were shining white, were easily seen with the naked eye, and were very irregular in size, some masses being ten times as large as others. The surface of the yolk was now roughened. The masses were made up of cells filled with granules. It seemed (though I may be hereafter corrected in this opinion) as if these balls were due to a rapid multiplication of blastodermic cells, resulting from the subdivision of the primitive cells of the blastoderm (fig. 6).

The artificially impregnated eggs did not develope farther, and remained in this state from the 8th of June until the end of July without materially changing. It will be desirable to repeat these observations and test their accuracy and I simply here place on record what I saw at that time, subject to farther correction. But the egg covered with the layer of pale nucleated cells, presented very much the same appearance as the blastoderm cells of the spiders as figured by Claparède[2] and what I observed in the eggs of Pholcus, which Mr. J. H. Emerton, then engaged in studying the embryology of our spiders, had the kindness to show me at the time of writing out these notes. They also accord with the blastodermic cells of *Gammarus fluviatilis*, in their earliest development, as figured by Prof. E. Van Beneden,[3] and another species doubtfully referred to this last form by Profs. Van Beneden and Bessels.[4] The formation of the blastoderm, then, if my observations are correct, exactly accords with that of the Arachnida, and the fresh water species

[1] Recherches sur l'Évolution des Araignées, etc.

[2] Recherches sur l'Évolution des Araignées, 1862. Pl. 1, figs. 1, 58, 59, 60.

[3] Recherches sur la Composition et la Signification de l'Œuf. Mem. Couronné, Acad. Roy. de Belgique, Tom. 34, 1870, Pl. 10, figs. 1-4.

[4] Mémoire sur la Formation du Blastoderme chez les Amphipodes, les Lernéens et les Copépodes, par Dr. Edouard Van Beneden et Dr. Emil Bessels. Mém. Couronnés et Mém. des Savants Étrangers, Acad. Roy. des Sciences, etc., de Belgique. Tom. 34, 1870. Pl. 2, figs. 16, 17.

of Gammarus; the yolk, as in these animals and all the insects, not undergoing segmentation.

The next changes in the eggs (observed May 27th, the day the eggs were received from New Jersey,) were not apparently of much consequence as regards the blastoderm, or formation of the germ, so far as I could ascertain. The peripheral yolk granules became collected into irregular white flake-like masses, varying greatly in size, and giving a rough outline to the yolk. Hundreds of these eggs presented the appearance indicated by fig. 6 *b*. The whitish flakes after awhile unite together as seen in fig. 7, and at the lower left side a large white mass is seen, formed by the union of these flakes. They thus unite together and disappear, the lumps flattening down, the contour of the yolk being again nearly as regular as before, while the yolk fills out the egg, the space between the chorion and yolk being greatly diminished. Usually one or several of these balls of yolk granules remain on the surface of the yolk, and may be seen after the germ appears, as at fig. 14, *x*. They become finally detached from the yolk and situated between the blastoderm skin and the chorion. In certain eggs they looked like rudiments of limbs, which I took them to be last year,[1] when the batch of eggs received from Mr. Lockwood had nearly all passed through this stage and the germ had developed.

The eggs after the flattening down and disappearance of the white spots, remain without farther perceptible change about a week before the germ or primitive disk appears so as to be visible. During this time the blastodermic skin ("amnion") is formed. The surface of the yolk is covered with irregularly hexagonal cells (fig. 8 *a*). In outline (fig. 8, profile of fig. 8 *a*,) they are seen to be spherical and filled with granules. They may be easily seen by reflected light with a triplet, and form a distinct layer resting immediately on the yolk. I could detect no nucleus in them.

Notwithstanding the apparent absence of nuclei I believe that these cells may be compared with the blastoderm cells of insects, as I have observed them in the Hymenoptera (*Nematus ventricosus*), the Coleoptera (*Attelabus rhois*), and the Diptera (*Pulex felis*), and as they have been previously observed in the Hymenoptera, Diptera, Coleoptera, Hemiptera, and Neuroptera (Libellulidæ), and Scorpions by various embryologists, especially Weissman, Metznikow, Melnikow, Brandt, and Ganin. The blastodermic skin, or "protoderm," of Limulus, as will be seen farther on, is moulted essentially in the same manner as in the scorpions and the hexapodous insects, and in all respects, both in its structure and function, it seems homologous with the protoderm of the class of insects so far as the orders have been observed.[2] Indeed Prof. E. Van Beneden remarks the "first

[1] The statement in the report of my remarks before the Association, and in the abstract printed in the Proceedings of the American Association, 1871, p. 247, that "one or two eggs were observed in process of segmentation" is entirely erroneous. The specimens were addled. So also must the statement that at first one pair, and afterwards three pairs of limbs appear, be cancelled. The six pairs of limbs as represented in fig. 12, appear all at once. I was misled by the peculiar arrangement of the whitish masses on the surface of the yolk. The inspection of a large number (several hundreds) of eggs in an earlier stage than in those observed in 1870 has enabled me to correct these errors.

[2] Dohrn says (Humphrey's Jour. Anat. and Phys., 1867) that "the 'amnion' of Scorpio is nothing but the carapace of Zoëa. So the amnion of insects is nothing but the carapace of Zoëa." Having as I think demonstrated that the "amnion" of Limulus is in all respects homologous with the "amnion" of insects, (and as we shall see farther on that it protects the embryo of Limulus *while in the zoëa condition*), how it can be homologous with the zoëa carapace I am at a loss to see. So far as regards the amnion of insects and crustacea, the two classes of articulates are parallel, it being present in both, and one class can hardly be considered in this respect as descendants of the other.

embryonic phenomena (*i. e.*, the formation of the blastoderm) of Asellus as well as Crangon, are entirely like those which have been observed in the Aphides by Metznikow, in the Arachnids by Claparède, in the fresh water Gammari and in a great number of the Arthropods," and we may now add in Limulus.

The protoderm ("amnion," "parietal membrane" of Brandt) as Bessels aptly terms it, is not moulted until after the primitive disk and the rudiments of the six pairs of cephalic limbs appear. In about a week after the protoderm appears, the primitive disk (fig. 10, *pm*,) is formed, as easily seen, by a local multiplication of the blastoderm cells on one side of the egg. (Fig. 9 represents a portion of the primitive disk consisting of protodermic cells resting on the yolk.) The protoderm or peripheral layer of these blastoderm cells (which form a thin bed enveloping the yolk, as I could easily trace the thin layer around the whole circumference of the egg[1]) begins to peel off at the depression or re-entering angle between the end of the abdomen and the yolk mass (figs. 12 *a*, 12 *b*, *a*). It gradually loosens as the rudimentary limbs become longer, and as they increase in length the protoderm peels off still more, leaving a clear space between it and the embryo, as seen in fig. 13.

The protoderm, then, in Limulus, though not moulted until after the formation of the primitive disk (the equivalent of the primitive band in Crustacea and insects) is a simple sac, and exactly homologous with the protoderm of insects. Though I could detect no nuclei in the protodermic cells, it will be remembered that they were easily seen in the primitive blastodermic cells (fig. 6, 6 *a*). This protoderm is evidently homologous with the protoderm of *Apus longicaudatus* Leconte, observed in alcoholic specimens. In this genus the chorion is thick, structureless, with irregular laminæ as in Limulus. The protoderm in eggs in which the germ has not yet appeared, though the yolk has somewhat contracted, presents exactly the appearance in outline as in Limulus (fig. 9, *p*), the cells being in profile spherical and projecting out in the same manner. In a vertical view they are rounded, more or less angular when crowded; in some cases with a nucleus, and in others not, so that the disappearance of the nucleus in the protodermic cells of Limulus is not apparently of great importance.

The protoderm of more advanced eggs just before the chorion splits, as seen in fig. 11 (11 *a*, profile view), becomes tough and dense. On a vertical view it is seen to be composed of irregular hexagonal cells, which are sometimes five-sided, and rarely four-sided; scarcely any two cells being alike (fig. 11). The walls of the cells are double, and are either strongly waved, or each side (sometimes but two or three) has from three to five long, slender projections, with the ends sometimes knobbed, directed inwards. The cells are usually packed closely together, but are occasionally separated by quite a wide interspace.

Having shown the homology of this protoderm in Limulus with that of the insects, let us examine its relation with the blastodermic skin moulted in other Crustacea. And here I may remark that the admirable and exhaustive papers on the embryology of the Crustacea

[1] E. Van Beneden shows in the eggs of Asellus that the blastodermic cells entirely surround the egg. The dorsal cells by their flatness and extreme delicacy are easily overlooked; and from this reason it was thought for a long time that the Arthropods in general, and especially the Crustacea, were deprived of a blastoderm on what is destined to be the dorsal side of the egg. But this opinion should be abandoned. In all, the blastoderm extends over the whole surface of the egg before the appearance of the rudiments of the appendages. Recherches sur l'Embryogénie des Crustacés. Bulletins de l'Acad. Roy. Belgique, XXVIII, 1869.

by Prof. E. Van Beneden, have by their clear views, based on a profound study of the earliest embryonic changes, afforded me the greatest aid in these studies. He has shown that in Sacculina, one of the Rhizocephala; in the Copepoda (Anchorella and Lernæopoda); in Gammarus, Asellus, Caprella, Nebalia and Crangon, and in the Acarina (the "deutovum" of Claparède), "the blastodermic cells secrete a first cuticular membrane." This "blastodermic cuticle" is secreted just after the blastodermic cells appear, at the time when the egg contains a protoplasmic mass charged with nutritive elements, which hold in suspension some cellular nuclei. In reality it is formed of a certain number of embryonic cellules recognizable by their nuclei, but not so by their contents. "It is at this moment that there is formed around the vitelline mass a very fine anhystic (*anhyste*) membrane, which is in our opinion a primitive (*premier*) embryonic moult; it is probably secreted by these primitive cells, and represents in some degree a first embryonic moult." This is not, as Claparède thought, the homologue of the "larval membrane" of Ligia and Mysis. Van Beneden is quite positive that this latter membrane no more than the nauplian skin, present in the eggs of all Crustacea, has nothing in common with the amnion of insects. And in this I would fully agree, on the evidence he presents, with the Belgian embryologist. I could not detect any such membrane in Limulus; the embryonic cellular membrane (protoderm) moulted (and not secreted) after the primitive disk has been formed, is directly homologous with the "amnion" of insects and the scorpions (it has not been observed in the spiders).

So far as I am aware Apus[1] is the only other crustacean in which a protoderm like that of Limulus is formed. Dohrn[2] remarks that cells are visible in the "amnion" of Oniscidæ and Idotea. It is not comparable with the nauplian or larval skin, as it is composed of distinct cells and is entirely circular, with no lateral diverticula surrounding the appendages. Why should this layer of blastodermic cells be thus thrown off and serve as a tough, dense protection to the embryo, even late in embryonic life, serving, instead of the chorion which splits apart and falls off, as a temporary egg shell; while in most other Crustacea, the blastoderm cells are absorbed? I think the reason is a biological one, and that the presence of this membrane is not of particular taxonomic importance. The eggs of Limulus are laid loose in the sand and remain there or are washed about by the waves during a month or six weeks, and possibly over a whole season. As the embryo increases in size, the tough, dense, inelastic chorion splits asunder rather than stretches, the dilatable protoderm enlarges, becomes dense and acts as a vicarious chorion. Zaddach[3] has described the same bursting of the chorion and the presence of what he calls a delicate internal membrane, which is in fact a protoderm, in *Apus cancriformis*.

[1] I know of nothing in the eggs of any other crustacean except Apus, comparable to this peculiar, inner egg membrane. In the eggs taken from the ovisac of *Apus longicaudatus* Leconte, and before the embryo has begun to develop, there is a similar membrane. It is very thin, free from, but lying next to, the structureless chorion. It consists of a single layer of irregular cells, varying in size, and often with a distinct nucleus. In a profile view of the uninjured eggs these cells are seen to be rounded and project out as in the inner egg-membrane of Limulus. As in Limulus, it does not assist in building up the embryo, and as in that genus, it is evidently a protective membrane, and brought into requisition at the time of the splitting and falling off of the chorion, to take its place, while it increases in size with the growth of the embryo. Zaddach (*De Apodis cancriformis Anatome et Historia Evolutionis*, pl. IV, figs. 1, 2, 3), represents the splitting of the chorion, and the embryo remaining in the inner, tender and pellucid membrane.

[2] Morphology of the Arthropoda. Humphrey's Journ. Anat. and Phys., 1867.

[3] De Apodis cancriformis, etc., pl. IV, fig. 3. Zaddach calls this "membrana interna," remarking that it exists in the ovary, and is afterwards accommodated to the body of the embryo. He does not notice its cellular structure. That this membrane is the same as the internal membrane formed in the ovary seems to us very doubtful, as we have endeavored to show that it is like the amnion of Limulus.

The freshly hatched young of Artemia, and probably all the Branchiopods, is at first surrounded by what Joly describes as a "membrane mince transparente." This seems homologous with the amnion of Isosoma, which I have noticed in the Memoirs of the Peabody Academy of Science, 1870. That was structureless, and it should be determined how far these amnion cells are absorbed in certain arthropods, as they seem to be in Crustacea generally, so far as our present knowledge extends.

Formation of the embryo. Between one and two weeks after the eggs are laid the primitive disk appears, bearing six pairs of appendages. Supposing that the germ appeared first as a simple, pale spot, and that the appendages appeared successively in pairs as in *Astacus fluviatilis*, *Palæmon adspersus*, and *Eriphia spinifrons* (observed by Rathke), I watched eagerly for two seasons, and examined at least over a thousand eggs, endeavoring to detect a primitive disk, without traces of appendages; but, probably owing to the opacity of the egg, with no success; though a few eggs the first season presented certain appearances which led me to suppose them to be the germ, some with one, others with three pairs of limbs. (See p. 159, note.[1]) The earliest appearance of the primitive band, or disk, is indicated by figs. 10 and 12. At this period the protozonites are faintly indicated, each bearing a pair of appendages forming flattened bands, which appear as if pressed down into the yolk, while the abdomen is indicated by a thickening of the posterior third of the oval disk, being paler than the rest of the body. The median line of the body is also seen at the same time. The germ is regularly oval, one-half as wide as the egg, and about two-thirds as long. Around the edge is a pale areola, destined to be the lower edge of the carapace; it is most distinct along the middle, merging imperceptibly into the anterior and posterior end of the disk. It is a thin ridge, due to a local heaping up of cells. The six pairs of appendages, at first forming simple bands, gradually increase in size towards the last pair. The first pair are much smaller than the other five and are situated considerably behind the mouth, which is very distinct. The abdomen is separated by a slight interspace from the preceding protozonite, while the areola merges imperceptibly into the abdomen. There are no traces of abdominal appendages.

At this time the disk is very flat, scarcely rising above the surface, and in profile is indicated by fig. 10. It is evidently due to the multiplication and heaping up on one side of the egg of the blastodermic cells, the layer forming the disk thinning out and surrounding the rest of the egg, as I could easily follow it around the entire circumference of the egg. Fig. 9 represents a portion of the disk, showing the layers of blastodermic cells (the outer layer of which is destined to split off and form the protoderm) resting on the yolk. The primitive disk in Limulus arises just as in Crustacea generally, as I have seen it in Lupa, Hippa, Idotea, and as described by other observers in other Crustacea; the great apparent differences in Limulus being probably at least due to the small size of the yolk granules, and consequent opacity of the egg, and to the small size and large number of the blastodermic cells, a circumstance of minor importance. Indeed the general features of the formation of the primitive band, of the protozonites, and the appendages of Limulus, accord not only with those of other Crustacea, but also strikingly with the Arachnida, and in only a less degree with the Insecta.

When the embryo is three days older (fig. 12 upper and lower figures from the same egg, 12 *a*, 12 *b*,) it is seen more distinctly, the disk becoming slightly thicker, especially in the abdominal portion. The blastoderm is thickest over the end of the abdomen,

thinning out over the space between the sixth protozonite and the base of the abdomen, and again becoming thinner over the anterior end of the head. It does not follow the contour of the body, but passes straight over the limbs. Moreover, there are indications that the superficial layer of the cells composing the blastoderm is peeling off, for at the suture between the end of the abdomen and the yolk, there is a slight rent (fig. 12 *b*, *a*) between the embryo and the skin, and this increases with the age of the embryo, peeling off from behind forwards. The appendages become more prominent, and in a day or two more appear as distinct tubercles. As the limbs grow longer they gradually push away the protoderm, the body of the embryo meanwhile becoming larger and outgrowing the blastodermic skin, as seen in fig. 13, where the embryo is a conspicuous raised disk, and the limbs form slender finger-shaped tubercles, with an external muscular layer, and within filled with yolk granules.

Fig. 15 shows the embryonic disk still thicker, while the yolk is more distinctly walled in by the tergal extension of the body walls. I am disposed to compare the embryo at this age, with the free swimming nauplius condition of other Entomostraca, especially of the Copepoda, though I am aware that the differences are very great, and that this opinion may not be shared by other observers. The adjoining cuts of the young of Branchipus (*a*) and Apus (*b*) give a fair idea of a nauplius of the Phyllopods, just after leaving the egg. The oval body, with the abdomen not yet differentiated, and bearing no limbs; the (usually) three pairs of limbs, representing the first and second antennæ and mandibles of the adult, together with the single eye, are the distinguishing characters of the nauplius stage. How does our Limulus embryo compare with this? There are six pairs of appendages, all arising from the head, and there are no abdominal ones; the abdomen is not yet separated from the body, though there are faint indications of a separation of what is to be the abdomen, from the anterior part of the body. Though there are in nauplius usually three pairs of appendages, yet not uncommonly there are but two (being probably the first and second antennæ). Nordman[1] figures the nauplius of several parasitic Copepoda which hatched with but two pairs; *i. e.*, *Achtheres percarum*, *Lernæocera cyprinacea*, *Tracheliastes polycolpus*; while in *Ergasilus Sieboldii*, belonging to another family of Siphonostomous Copepoda, the larva is provided with three pairs of appendages, as in the larvæ of all the free swimming Copepoda, and the Cirripedia. Ascending to the Cladocera we find that Dohrn[2] has figured the nauplius stage of the embryo of Daphnia with three pairs of appendages, and it is in some respects farther developed than the embryo of Limulus, in having at the same time a rudimentary upper and under lip. In the Phyllopoda the larva of *Limnadia Hermanni* is figured by Lereboullet[3]; there are but two pairs of appendages, which finally become the first and second antennæ, and an enormous labrum is developed. The larva of *Artemia salina*[4] and

[1] Micrographische Beitrage zur Naturgeschichte der wirbellosen Thiere. Heft 2, 1832.

[2] Untersuchungen über Bau und Entwickelung der Arthropoden. Heft 1, Taf. 1, fig. 8, 1870.

[3] Observations sur la Génération et le Développement de la Limnadia Hermanni Ann. des Sc. Nat. 5ème Ser. Tom. 5, 1866, pl. 12, figs. 1, 2.

[4] Joly, Histoire d' Artemia salina, etc., Ann. des Sc. Nat. 2d series, Tom. 30, pl. 7, figs. 4, 5, 6.

Branchipus, and probably all the Branchiopodæ, have three pairs of limbs, which become the two pairs of antennæ and mandibles of the adult. Zaddach[1] figures the larva of *Apus cancriformis* as having but two pairs of appendages, which finally become the two pairs of antennæ of the adult. The nauplius stage of Nebalia, according to Metznikow's figures, as in that of Limulus, is passed within the egg; it has three pairs of limbs, and rudiments of the abdomen appear. It appears, then, that the number of nauplian appendages in the Entomostraca is inconstant, and though the embryo of Limulus has so great a number as six pairs, they are all cephalic and therefore homologous in their regional position to those of nauplius-like larvæ. No eye spots can be detected to compare with the single eye of most nauplii, but no eye is developed in Daphnia, according to Dohrn's observations, and indeed the only organ of vision, the compound eye, is developed late in embryonic life; neither is there in Leptodora according to P. E. Müller. The nauplian stage of Nebalia is eyeless.

We feel justified, then, in regarding this stage of Limulus as representing, though imperfectly, the nauplius condition of the Entomostraca. Thus Limulus may possibly trace its ancestry back to an ancestral nauplius-like being; and as the number of limbs may have been increased in the progress of development of the Limulus form, we can readily imagine that the ancestral forms at the time when they were hatched as nauplii and not as subzoëæ, had no more than perhaps three pairs of limbs, their growth in the egg being then greatly accelerated to allow of their hatching in the nauplius stage, in contradistinction to their present retardation in the egg until the form of the adult subzoëal Limulus is attained.

The subzoëa stage. The next stage of the embryo is signalized by the appearance of the two basal pairs of abdominal appendages (fig. 16, *ab*), with an accompanying enlargement of the abdomen. The arthromeres are also indicated beyond the areola, the sutures extending upwards but not reaching the dorsal side of the egg. These changes occur some time before the splitting apart of the chorion. The abdomen having grown a little longer (the embryo now being about three-fourths the length of the yolk), two oblique, pale bands, being local thickenings of the germ, can be detected on each side of the median line of the body, and just behind the last pair of limbs. The cephalic feet have meanwhile increased in length and are folded upon themselves.

At a still later stage the embryo, observed June 21st, covers more than one-half of that portion of the yolk in sight, and there are faint indications of the four median sutures on the tergal surface of the yolk, showing that the yolk is surrounded by the subzoëal skin. The areola is still well marked. The limbs are longer, but no joints have appeared, and the rudiments of the foliaceous abdominal legs have become more apparent. In the same egg, observed the next day, June 22d (fig. 17), the whole body has grown much wider, and especially the abdomen. The sutures between the segments are much deeper and broader, the legs have become three-jointed, two sutures appearing. The end of the abdomen is broad and there are but two arthromeres, exclusive of the terminal one. In a side view (fig. 17 *a*) the increased size of the limbs is shown and the larger size of the basal abdominal arthromere, or rudimentary gill-foot, as compared with the second one. The embryo now revolves within the protoderm, which has somewhat increased in size, leaving a greater space than before between it and the embryo, for its rotatory movements.

[1] De Apodis cancriformis, etc. Pl. 4, fig. 3.

Two days after (June 24th), the same egg appeared as in fig. 20. This stage may be known by the differentiation of the abdomen, and the appearance of a third pair of abdominal limbs, together with the origin of the claws. The compound eyes also appear as two white dots on the third segment of the cephalothorax. The ocelli appear still later and are situated on the mandibulary, or first segment. It is thus proved that the eyes are not in Limulus developed on distinct segments. The nine abdominal arthromeres, or rings, have appeared, no more being added during after life; there are six well marked cephalothoracic segments. The whole body of the embryo is spherical, being as thick through as it is broad. The tergal side of the abdomen is about one third thicker than the pleuro-ventral, the surface of the latter being very convex. The segments of the abdomen gradually increase in size, the ninth, or rudiment of the spine, being scarcely longer than broad, and those next to it being very much curved, so that towards the outer margin they are almost parallel with the median line of the body. The inner claw is developed as a tubercle on the inner side and at a considerable distance from the tip of the limb, in after life gradually becoming as large as its fellow. The rudiments of the flagrum or outer division of the fifth pair of maxillipeds, are also prominent, beginning as tubercles. At this stage the chorion bursts open, the protoderm increases greatly in size, and a corresponding amount of sea water is absorbed, in which the embryo freely floats. The two halves of the chorion are held together by a slight hinge, and some separate from the egg. The dorsal vessel is now distinct, appearing as a pale streak extending from the front edge of the cephalothorax to near the end of the abdomen, and situated in the median depression of the body.

In another egg (fig. 19, 19 *a*) observed July 4th, but which was not quite so advanced as the stage just described, the chorion not having yet split apart, the six cephalothoracic and nine abdominal segments are well seen, the sutures forming deep depressions in the yolk, which is pale green as before, and lobulated just within the integument. The bases of the limbs are nearer together, and the line between the cephalothorax and abdomen may be distinctly seen, the posterior edge of the former projecting out sensibly beyond the sides of the abdomen.

June 27th, in the egg under observation June 22d-24th, the two basal pairs of abdominal feet have become more prominent, being thinner and more lamelliform, the third pair being still minute.

On the succeeding day, June 28th, the curved hamulate form of the flagrum (fig. 21. *f*) is apparent, and the lower edge of the cephalothorax is thickened and incurved. The rudimentary heart is more distinct than before. At this stage the embryo moults its skin. It is gradually shed, the specimen under observation requiring several days for the operation, a period considerably longer than in a state of freedom probably, when the water is better aerated; two days after it was first observed, the skin had been drawn off the cephalothorax and remained attached to the abdomen. It was so thin that it was simply pulled off from before backwards, not exuviated as in the larva. It begins to be shed, as other specimens showed me, at a little earlier period, before the claws begin to be developed, as represented in fig. 18 *a*, *z* indicating the skin partially peeled off. It may then be seen floating about in the protodermic fluid, entangled in the limbs of the embryo. This skin cannot be compared with the "larval skin" of the Isopods, as I have observed it in a species of Ligia at Key West, and in *Jæra copiosa* of the shores of New England, and as described by Fitz

Müller (Für Darwin) in Ligia and other genera of Isopods, and by Prof. E. Van Beneden,[1] who has given the most careful description of it in Asellus, describing its origin. It is to be borne in mind that the larval skin of the Isopods is a sac, as Müller says "quite destitute of appendages," which surrounds the body of the embryo until it is ready to hatch. E. Van Beneden remarks of this simple envelope in the Isopods, that "Fitz Müller has demonstrated the analogy which exists between the larval membrane of Ligia[2] and the nauplian skin of the embryo of Mysis,"[3] (a low decapod, "the near relationship of which with the shrimps and prawns has recently again been generally recognized," as Müller remarks). "Both are the homologues of this membrane that the nauplii of the lower crustacea secrete at their surface." Van Beneden then shows that of the two embryonal membranes or skins, the first moult is a blastodermic moult, the second a nauplian, which also corresponds to the larval membrane of Ligia, but differs in having appended to it the rudiments of the first and second pairs of antennæ.

This larval membrane of Limulus cannot be a nauplius skin,[4] because it is shed when the embryo has attained to its true subzoëal state; and the membrane instead of being a simple, rounded sac as in Ligia, or with the appendages (*i.e.*, the two pairs of antennæ) as in Asellus, or with these and the mandibles, as in Mysis, is provided with the full number of appendages, and is thrown off like an ordinary moulted skin, and does not serve as a protective membrane. The embryo has simply outgrown its old skin and cast it off, just as it moults from time to time after hatching. This embryonal moult is simply the first of a series of larval moults, and at the time of this first moult the larva has taken on its essential zoëa-shape, with its abdomen differentiated from the head, and its two pairs of eyes, simple and compound, and full complement of feet.

Having at first, though with many misgivings, considered this moult a nauplian one, I am led to consider it as rather analogous to the third moult described by E. Van Beneden, in his beautiful memoir on Asellus. He shows that certain Anchorellæ and some Lerneopods after undergoing a blastodermic moult, accomplish a second (a nauplian moult), which is formed "when the embryo is provided with three pairs of appendages characteristic of the form of nauplius." This corresponds, he thinks, to the larval skin of Ligia and the nauplius skin of Mysis. "In this second cuticle, the embryo continues to develop, and we see appear a series of six pairs of appendages in the Anchorellæ, and five pairs in the Lerneopods. The embryo attains the cyclopean form, which is, in our opinion, morphologically identical with the form of zoëa. It then secretes at its surface a third skin, which is the cyclopean or zoëan skin; and the young Anchorella, as the young Lerneopod, comes into the world

[1] Recherches sur l'Embryogénie des Crustacés.—1. Observations sur le Développement de l'Asellus aquaticus. Bulletins de l'Academie Royale des Sciences, etc., de Belgique. 2me Sér. Tom. XXVIII, 1869, p. 54.

[2] "As in Mysis also, a larval membrane is first of all formed, within which Ligia is developed. In Mysis this first larval skin may be compared to a nauplius; in Ligia, it appears like a maggot quite destitute of appendages, but produced into a long simple tail. The egg-membrane is retained longer than in Mysis; it bursts only when the limbs of the young Ligia are already partially developed in their full number. The dorsal surface of the Ligia is united to the larval skin a little behind the head." Für Darwin, English Trans. p. 69.

[3] "The young animal might be called a nauplius; but essentially there is nothing but a rough copy of a nauplius skin, almost like a new egg-membrane, within which the Mysis is developed." l. c. p. 65.

[4] At the time an abstract of this paper was presented to the American Association for the Advancement of Science, I called this a nauplius skin, but with much doubt at the time. It is evident, however, that Limulus passes through a nauplius state, at a time previous to possessing its full complement of legs, during a period between that indicated by figs. 15 and 16; though it does not shed a skin at this period.

under this form. The embryo of these Lerneans then passes successively through the phases of blastoderm, of nauplius and of cyclops, and at each of these states, it secretes at its surface a cuticular membrane; it undergoes successively a blastodermic moult, a nauplian moult, and a cyclopean moult."

It is probably with this cyclopean skin that the moulted skin of Limulus is homologous. But I should venture to differ from M. Van Beneden in considering that any Copepod with simple eyes and no distinct abdomen and head, such as Cyclops and others, sheds a zoëa skin, as I would limit the term zoëa to the larvæ of the Decapoda, and such Branchiopoda as possess in the larval state a pair of compound eyes, in addition to simple ones, and that have more than three pairs of feet, such as most nauplii have, and furthermore possess an abdomen more or less differentiated from the head, or, when it exists, cephalothorax. Examples of such zoëæ among the Branchiopoda are the later larval condition of the Branchiopodidæ, Nebaliadæ, and the larvæ of Limulus and the Trilobites.

A little farther on in its development the body, from being spherical, flattens and grows wider, the sides of the cephalothorax extending out, while the abdomen is folded upon the body. Still later, July 1st, the trilobitic shape (figs. 24, 24 *a*, side view; 24 *b*, ventral view) is assumed, just previous to hatching. The trilobate character of the tergal surface of the body is very marked, the cardiac, or median region of the body being considerably raised above the sides, and on the abdomen the sutures do not run continuously across the tergum, but are interrupted at the edge of the cardiac region, thus making the latter more distinct. The sutures between the segments are sinuate, as in the Trilobites, and the eighth segment is parallel to the median line of the body, as well as the ninth, which forms the rudimentary spine. The outer edge of each segment is convex, the convexity greatest on the hinder portion of the edge, as in the Trilobites. The lateral region on the cephalothorax is limited by the slight ridge on which the ocelli and compound eyes are situated, which may be called the opthalmic ridge. The green yolk is still lobulated along the edge with six lobes on the lateral region, indicating the six cephalothoracic segments. The sternal portion of the abdomen is now flattened, having been absorbed, so that on a side view it cannot be seen, nor even the abdominal legs. These last are at first a little less than one-half their size in the fully formed embryo (fig. 24), and the median sinus between each leg is greater in the first pair than in the second. The rudimentary feet in the first, or basal pair, form a minute tubercle (fig. 22) on the inner edge of each gill-bearer. Those of the second pair are much larger, being long, slender, nonarticulated processes directed obliquely outwards. The maxillipeds are much as in the larva, the coxal joint having a stout spine directed inwards; but it is not until after several moults that the numerous spines which form the masticating surface appear. The claws are acute and long. Fig. 23, *a*, *b*, represents the terminal joints of two of the anterior maxillipeds, and 23, *d*, the terminal joints of the fifth pair, the six spatulate spines on the penultimate joint of the adult being now simple spines, and the terminal forceps being quite complete. Just behind the last pair of maxillipeds are a pair of oval, rather flat, tubercles; their bases are united on the median line of the body, thence diverging outwards. These tubercles do not appear much before this period in the life of the embryo. They have no connection with the last pair of maxillipeds, nor can they be, as Savigny supposed, the rudiments of a seventh pair of legs, otherwise they would have appeared earlier in embryonic life. It will be seen by reference to figures 24 *b*, and 25 *a*, that they close up the posterior end of the

sternal groove. In adult life, they are moveable at their bases and armed on their inner side with powerful spines, like those on the maxillipeds; hence they serve two purposes, namely, of completing the circumoral cavity, in which the food is retained by the spines of the surrounding walls, and of directly aiding in triturating the food and preparing it for deglutition. Savigny has considered it as functionally a sort of inferior lip. It apparently corresponds to the postoral plate or epistoma of Hall (metastoma of Huxley), of the Eurypteridæ, where it forms a solid, heart-shaped, oval plate; its position seems nearly identical, though set farther from and partially covering the base of the last pair of feet. Its great development and unpaired form seem correlated to the difference in the form and functions of these feet as compared with those of Limulus. Woodward says of the metastoma that "it no doubt represents the labium, and serves more effectually to enclose the posterior part of the buccal orifice, being found exterior to the outside edges of the ectognaths or maxillipedes." Latreille has applied the term epistoma to the clypeus of insects, and as this postoral plate is in no way homologous to the labium or second maxillæ of insects, the term metastoma applied by Huxley is very appropriate.

The ocelli are situated in an earlier period of this stage than that represented by fig. 24, on the under side of the head just in advance of the mandibles, and are at this time white and irregular in shape, being a little longer than broad. A little later they appear on each angle of the front edge of the cephalothorax; the edge being afterwards expanded and extended, so that as in fig. 24 they are placed a little way in from the edge. The eyes also are at first rounded white tubercles, becoming in more advanced specimens black along the front edge. The protoderm measures at this period, .13 of an inch in diameter. Of the eggs laid in the middle of May one was hatched June 30th, the majority came out of the egg about the 14th of July, and the remainder kept hatching until the last of September, in my jars. In the succeeding summer (July, 1871) the hatching jar, in which the water had remained unchanged since the previous October, and with no weeds to oxygenate the water, contained several embryos in eggs laid during the preceding year, in different though advanced stages of development, and also several larvæ hatched during 1870, though in a torpid state, due probably to the little air in the water. I much doubt whether the eggs of any other living crustacean would show as much vitality. It should also be noticed that these eggs had not probably grown during the winter, but remained as it were in a state of suspended animation from October to July, a period of nine months. These facts confirm the remarkable observations of Rev. Dr. Lockwood on the wonderful vitality of the eggs of Limulus. He remarks, "at the close of the warm season last year [1869], my jars must have contained not less than two hundred young Limuli. We have already said that so soon as hatched, the young burrow like the adult; hence the rareness of an opportunity to witness the casting of the skin. Hoping to continue my observations upon the growth of my interesting family the ensuing year, the jars were carefully put away. Little regard, however, was paid to temperature, which, on several occasions, went down to the freezing point. On the 3d of May, 1870, I emptied the jars to see how my charge was getting on, when lo, not one of the last years' hatching was alive! but wonderful to say, at least a dozen little fellows, all hatched this spring, and all alive, had taken their place. With these were also at least thirty eggs, in different, but all in advanced stages of incubation. In some of them, the young could be plainly seen revolving. The fact is, these eggs had been at the bottom of the hatching jar, and

never had any contact with the sunlight. At once, not without some misgivings as to the result, the proper provision was made to complete the incubation, namely, new sea water, clean sand, the eggs put on top and all set in a favorable place. With an ordinary hand lens the progress of incubation could be observed daily. At half past four o'clock on the afternoon of May 11th, before my eyes, a new-born baby Limulus left the egg. Just think of it—these eggs are within two weeks only of being a year old! And then how remarkable are these facts also; these eggs were incubated last summer! Hence there has been not only a remarkable retardation of development, but also an actual arrest of the same for seven or eight months without sacrificing life."

The larva state. The larvæ, as we shall call the young before they have undergone their first moult, are very lively, walking over the jar and burrowing in the sand at the bottom and occasionally swimming to the top, or skimming obliquely over the bottom by vigorous strokes of their abdominal feet. Mr. Alex. Agassiz informs me that he once captured a specimen swimming on the surface three miles from shore. This fact indicates that this species owes its wide range from Maine to the Gulf of Mexico and the West Indies, to the swimming habits of the larvæ. The principal differences from the embryo just before leaving the egg are these—the abdomen is larger in proportion to the cephalothorax, it being a little broader and longer; the sinuate sutures defining the segments of the abdomen are nearly obsolete; the lobes of the liver do not reach so near the edge of the carapace, and the edge is fringed with hairs; these differences being very slight.

The cephalothorax is about one-half as long as wide, each half being a quadrant of a circle. The integument is pale horn color and very transparent, while the liver and cardiac region of the abdomen are pea green; minute granules are scattered over the integument. The edge of the carapace is fringed with fine, slender hairs, thirty-six on each side; they are wanting in a short space on the median line of the carapace, and at the posterior angle, and on the hinder edge. They do not arise from the extreme edge, but from little sockets placed on the upper side of the edge. They project upwards and forwards and hence lie back on the carapace when the animal is burrowing. Just within this hair-bearing edge is a solid space, or line, its inner edge being the wall of the general cavity of the body, the blood circulating next to it. The edge of the carapace along its posterior half is minutely toothed; there being about five saw-like teeth between the hairs, the teeth pointing backwards. The "frontal doublure" or triangular area in front of the mandibles is not seen from above, but beneath is quite small compared with the same part in the adult. The ophthalmic ridge (so named since the eyes and ocelli are situated upon it, and as it separates the cardio-ophthalmic region from the lateral region of the carapace) is distinct, but still much slighter than later in the larval stage, and without the teeth overhanging the eyes (though there is a swelling instead), and also without the median tooth on the posterior edge of the cephalothorax; this appears, however, before the animal moults. The eyes are oval, and placed obliquely, the posterior end being directed inwards; the anterior three-fifths of the surface is black, the pigment cells are continued in front of the eye along the ridge, forming a faint black line. The ocelli are two round black dots separated by a space twice their diameter in width. In a transverse section, the cardiac region is very prominent, convex, carinated, and, with the high cardio-ophthalmic region and rapidly sloping edge, resembles strikingly the glabella of a trilobite. The cardiac region of the abdomen is convex and carinated, and retains the sutures between the segments much more distinctly than the

sides, and the green yolk mass beneath, not entirely absorbed, is also deeply subdivided and lobate on the edges. The edge of each segment is toothed, the basal tooth being the largest, the succeeding serrations being fine, and with a moveable spine inserted on the hind edge of the tooth, and projecting beyond it. Between these teeth are three or four (the number varies) very minute short hairs. It is .13 of an inch in length and .11 of an inch in breadth.

The legs are much as in the adult, the coxal spines, with the exception of one or two, not being developed until after several moults. The fifth maxilliped (fig. 23, *c*) has six spines on the penultimate joint, which have not yet assumed their spatulate form, but the terminal forceps is much as in adult life. The first pair of gill-bearing abdominal legs (fig. 26, *a*) are now much longer than before, with a long, dense fringe of fine hairs. Each leg is semi-ovate in form, with no appendages, and with a suture at the basal third extending two-thirds of the distance from the outer edge to the inner, where it forks, enclosing a triangular area, covered with a few hairs, increasing in length towards the inner edge of the leg where it is coalesced with its fellow, having been separated in embryonic life. The two legs are united to form one piece, dividing on the outer third. The second pair reach a little beyond the edge of the basal pair, and resemble those of the embryo, bearing a distinct jointed limb. Fig. 25, *b*, represents the larva in a front view; 25, *c*, in a back view, with the abdomen bent with the cephalothorax; and 25, *d*, a profile of the body when extended, for the sake of comparing it with similar positions of the Trilobites.

The young after the first moult. The larva moults its skin during the last week in July, about the 25th of the month, or about three weeks after hatching. The principal changes are the possession of a short abdominal spine, the origin of a fourth pair of abdominal legs and the appearance of additional joints to the basal ones, and the smaller, but more numerous lobes of the liver, which do not reach so near the edge of the carapace as in the larva, or as in the adult when a foot in length.

The eyes are as in the larva, partially black. The abdomen now more nearly resembles that of the adult; the acute side of the basal segment forms a revolute spine, and the succeeding teeth are much larger than in the larva. The spines are minute and slender and scarcely extend beyond the teeth, though so much larger in proportion in the adult. The terminal spine is inserted in a deep lobe, or sinus; in the eighth ring the lateral spine on each side reaching to its middle. It is broadly ensiform, being subacute and about three times as long as broad; it is thin, hollowed out beneath, the convexity being angular. The base of the spine is situated at quite a distance from the edge of the abdomen, embracing the anus which opens in it.

The fourth pair of abdominal legs are small, and concealed under the basal ones. The first pair differ from those in the larva in being longer in proportion to their width, and in having an additional joint at the base, the suture extending about half way in to the inner edge. The two limbs are united more closely than before, dividing much nearer their extremities. The second pair are now three-jointed, each leg with a slender, two-jointed, free tarsal termination, and a lobe just external to it. There are five lamellæ to the gills, attached to the basal joint. The fringe of hairs is much shorter than on the basal pair.

It is .25 of an inch in length. The circulation of the blood (Pl. v, fig. 27) can be observed much better after the young Limulus has moulted its integument once, the body being more transparent than before. The heart, already described by Van der Hoeven,

is a long fusiform tube (as seen in the living animal), lying immediately over the alimentary canal, and rather shorter than the latter. It beats ninety times a minute, after the first moult. The anterior end is rounded (the origin of the main artery not being in view), with a slight constriction just behind, while the posterior end gradually diminishes in width, ending at a little distance in front of the anus. There are seven pairs of venous openings guarded by valves, the venous openings being vertical slits, alternating slightly, one opening a little in advance of the one opposite. Those in the cephalothorax are larger than the abdominal ones, gaping wider. There is a wider interval between the second thoracic and the first abdominal pairs of venous openings than between the others. I could not detect the pericardium, but could see the blood globules moving to and fro in the pericardial cavity. Straus Durckheim,[1] Van der Hoeven,[2] and Owen,[3] describe six arteries, three of which are sent off from the head, and three from the posterior end of the heart. I am not aware that they have noticed an additional pair thrown off from near the middle of the heart, and just in front of the hinder end of the cephalothorax. My attention was called to them by a steadily flowing stream of blood discs flowing away from the heart, at right angles to it. No venous openings in the heart could be seen at this place. In the figure (Pl. v, fig. 27), the course of the arteries is represented by feathered arrows; the venous currents by simple arrows. Authors describe the anterior end of the heart as terminating in an aortic trunk, which throws off three arteries; a median one towards the ocelli, and a lateral pair of larger ones which curve down under the œsophagus. I could not see the walls of any of the arteries, and indeed the arterial blood seemed to flow in channels exactly like the venous sinuses, as in the arteries which pass around the margin of the carapace the blood discs were seen to pass by irregular currents towards the front edge of the margin. The anterior aorta could not be detected in the young Limulus, but on each side of the end of the heart the blood could be seen rushing out and in, and with a general course downwards, beneath the œsophagus, while a current of blood flowed on each side of the stomach and œsophagus, and thence went out at a considerable angle to the edge of the carapace, where it divided, sending a branch around under the ocelli, and another along the outer edge of the cephalic shield, and again subdivided opposite the second pair of cardiac valves, one current following the edge of the cephalothorax, and the other going in towards the heart. The marginal artery continues around the edge of the abdomen, the current of blood turning upon itself before reaching the caudal spine, and flowing towards the heart. The abdominal arteries, represented by powerful currents of blood issuing from between the two last pair of cardiac valves, are directed obliquely outwards and backwards. The caudal aorta sends a current nearly to the tip of the spine, the venous sinuses returning it along the sides. The simple arrows mark the course of the returning currents, which flow from all parts of the body towards the valves.

In the legs a current passes towards the claws along the inner side, and back by the outer side; the main current crosses over to the base of the larger claw, sends a small

[1] Considerations générales sur l'Anatomie comparée des Animaux articulés. Strasbourg, 1828.

[2] Recherches sur l'Histoire Naturelle et l'Anatomie des Limules. Leyden, 1838.

[3] Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals. London, 1843. (I might add that the observations here recorded were made on the living animal, without the aid of dissection, and do not intend to give the entire anatomy of the circulatory system, but that of those parts only that may be seen from a dorsal view.)

stream, with an occasional disc, into the base of the inner and smaller claw; in the larger claw the current passes around a sort of septum, and returns along the outer side.

The liver arises from two branches, emptying into the alimentary canal near the two anterior pairs of cardiac valves; the anterior branch subdividing into about six main lobes, their lobules all ending at an equal distance from the margin of the cephalothorax; the posterior branch sends one simple lobe into the abdomen, situated next, and extending nearly to the end of the heart; the other lobe is distributed to the posterior part of the cephalothorax. The alimentary canal terminates near the base of the spine; anteriorly it forms a bulb-like swelling. The stomach moves back and forth as the œsophagus is protruded in and out. The lobes of the liver are slenderer and more numerous than in the larva.

After a second moult of the integument, which occurred Aug. 15—30, the young Limulus is .40 of an inch in length. On the 1st of July a specimen was brought me which was a little over an inch and a quarter long. I think it must have been hatched the previous summer, and that it was consequently about a year old; showing its slow rate of growth.

We are again obliged to turn to Mr. Lockwood's valuable article for information relative to the number of moults Limulus undergoes. He says "the exuviation of the King Crab is performed several times during the first year, and at very short intervals. How many I do not know, as that must vary according to the time of hatching. But I think the young produced in the latter part of June will accomplish five or six moults before the cold weather comes." He thinks an individual an inch long is a year old; this is my own conjecture. He also states that in February, during unusually warm weather, an adult female was taken in Raritan Bay, N. J., which had recently cast its skin, as "its shell was still quite soft."

Regarding the time of sexual maturity, and the period when the external sexual characters appear, we must depend for our information on the researches of Mr. Lockwood. He thinks that the time of puberty cannot come before the third or fourth year, and considers that the latter figure may prove the minimum. It is not until this period is reached that "the male undergoes its last metamorphosis." It then moults, and the anterior claws assume the peculiar shape of that sex.

Comparison with the development of other Branchiopoda. In comparing the embryology of Limulus with that of other Branchiopoda, we are met by an exceptional mode of formation of the germ; just as among the Decapoda, the development of Astacus, and three or four other species of crabs, and among the Amphipoda the development of the fresh water *Gammarus fluviatilis* and *pulex* of Europe, is an exception to the general law of development in those groups. So that it is difficult to make a comparison of the mode of formation of the germ of Limulus with that of Daphnia, and other Cladocera, and the Phyllopod genera, Apus and Branchipus. We have extended investigations by Zaddach,[1] Leydig,[2] Lubbock,[3] P. F. Müller[4] and Anton Dohrn,[5] on the embryology of Daphnia, to

[1] Untersuchungen über die Entwicklung und den Bau der Gliederthiere. 1 Heft. Die Entwicklung des Phryganiden-Eies, 1854, p. 96, where he describes the development of the limbs in *Daphnia sima*, not describing the earliest changes in the egg.

[2] Naturgeschichte der Daphniden, 1860.

[3] Philosophical Transactions, London, 1857.

[4] Danmarks Cladocera, in Naturhistorisk Tidsskrift, Kjobenhavn, 1868.

[5] Untersuchungen über Bau und Entwicklung der Arthropoden, Siebold und Kölliker's Zeitschrift fur naturwissenschaftliche Zoologie, 1870.

rely upon, regarding the egg and embryonal membranes, and the formation of the blastoderm. Dohrn describes the egg of Daphnia as being transparent, with a peripheral primitive layer (*Keimschicht*) surrounding the yolk, and a chorion. The primitive band entirely surrounds the yolk, and the rudiments of the limbs arise as in other Crustacea.

The mode of formation of the primitive band in Limulus was not observed, but I believe that I have given facts sufficient to show that it forms the thickened portion of a layer of cells which surrounds the whole yolk. At the earliest period observed, it was, however, confined to a small portion of the ventral surface of the egg, forming a local thickening of the blastoderm, resulting (as Claparède has clearly shown in the eggs of the spiders,[1] Pholcus, Clubione and Lycosa, where the germ forms a broad band on the ventral surface of the yolk), from a multiplication of the blastodermic cells, which are much smaller than elsewhere. This primitive band, according to Rathke's researches, becomes still more local and circumscribed than in the spiders and scorpions, in *Eriphia spinifrons*, *Palæmon adspersus*, *Crangon maculosus*[2] and *Astacus fluviatilis*,[3] and he calls it the "primitive disc" (*Keimscheibe*). In the eggs of all other Crustacea whose development has been studied, the primitive band surrounds the whole yolk long before the limbs bud out, and is not gathered into a small, ventral disc. Now all the above named ametabolous Decapoda and Amphipoda undergo no metamorphosis after leaving the egg, neither do the spiders and scorpions, while the metamorphosis of Limulus is very slight. The question naturally arises whether there is any connection between this origin of the embryo from a primitive disc, so exceptional a case in Crustacea, and the equally exceptional ametabolous growth of the same species of Crustacea?

While the Cladocera (Daphnia and others) escape from the egg with their full number of limbs, and with the general form of the adult; the larvæ of Apus (see p. 163, the young after the first moult) and Branchipus leave the egg in the nauplius stage, comparable with the larvæ of the Copepoda and, in a less degree, with those of the Cirripedia, and afterwards pass through a well marked metamorphosis. Fritz Müller[4] also states that the Phyllopoda "have to undergo a metamorphosis. It seems to be more marked, however, in the genus Nebalia, which Mecznikow says 'passes through the nauplius and zoëa stages, which, in the Decapoda, occur partly (in *Penæus*) in the free state.' Therefore I regard Nebalia as a Phyllopodiform Decapod.[5]"

The Phyllopoda also, without exception, so far as our knowledge extends, bear their eggs about with them until the young are hatched. The eggs of the Cladocera are borne in special cavities, or "brood-holes," while they are carried about in the Phyllopoda somewhat after the manner of the Copepoda, or are placed in ovisacs appended to the base of the abdomen. The eggs are fertilized from the union of the two sexes. Limulus is an exception to this rule, the ova being deposited loose in the sand of the sea shore between tide marks, where they are probably fertilized by the spermatozoa of the males floating free in the water, and are left by the females to the mercy of the wind and waves.

Though the embryo of Limulus is hatched with the cephalothorax and abdomen, and with

[1] Recherches sur l'Évolution des Araignées. 1862. Utrecht.

[2] H. Rathke. Zur Morphologie. Reisebemerkungen aus Taurien. 1837.

[3] Rathke. Untersuchungen ueber die Bildung und Entwickelung des Flusskrebses. 1829.

[4] Für Darwin. Leipzic, 1864, p. 56. English Translation, London, 1869, p. 83.

[5] Quoted by Müller. Für Darwin.

its full number of legs, we should not be justified in calling it a nauplius, or, on the other hand, a zoëa, in the full sense of the word, and for its singular form I would use the provisional term *subzoëa*. The larval form is, like that of the Trilobites, a remarkably exceptional one, and corresponds with its mode of life; for, as we have seen above, it immediately after hatching creeps over the surface of the sand or mud, or burrows deep after its food. Swimming is an exceptional act, as I have found by watching them day after day for three months in succession. Hence their mode of life does not demand a nauplian, or complete zoëa form.

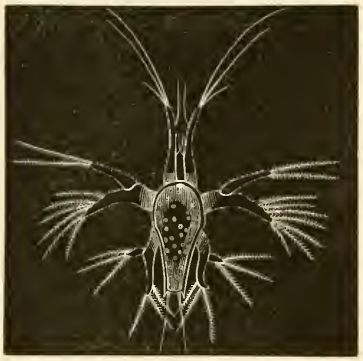


Fig. 28. — Nauplius of Penæus.

Among other exceptional features in the egg is the remarkably tough chorion, and the protoderm, with its cells retained, and even enlarged, which, so far as I am aware, is an exception to the eggs of other Crustacea, and of insects; as also its enormous increase in size during the growth of the embryo. It is well known that the eggs of many insects and Crustacea do increase, and even double in size; but this is generally attended by a change in form of the embryo, which from being round becomes ovate; no instance, however, is known to me among the Arthropoda where the amnion increases four or five times in size, as that of Limulus does, and where, at the same time, the membrane is perfectly spherical.

Homologies of the Merostomata. Regarding the number of segments in the body of Pterygotus, Mr. H. Woodward[1] remarks: "In describing the divisions of the body in *Pterygotus Anglicus*, we have spoken of the head and the body, avoiding the terms 'thoracic' and 'abdominal somites' as much as possible. On reference to the restored figure at plate VIII, fig. 1, it will be seen that there is evidence, according to the paired appendages, of seven somites having coalesced to form the cephalic division. Assuming that all the segments united to form the head are represented by pairs of appendages, we have then a true cephalon; the seven succeeding free somites are thoracic, the abdomen being represented by five somites and a telson, or terminal joint. But assuming the antennules to be wanting [according to Huxley's opinion], we must conclude the head to represent eight coalesced segments, that is to say, seven cephalic and one thoracic, the latter bearing the 'operculum,' or thoracic plate. In this case only the first six anterior somites will be counted as thoracic, the posterior six will be reckoned as abdominal, and the 'telson' will make up the twenty-one segments. The likeness which Pterygotus offers to Limulus is very much strengthened by this latter view. As we proceed to the illustration of the other genera belonging to this order, we shall be still more strongly impressed with the many points of close resemblance which they will be found to exhibit."

Having observed that the ocelli of Limulus are developed on the first segment of the head, which is to be regarded as the first antennary segment, and that the compound eyes are developed on the tergal side of the third, or mandibulary segment, I have been led to

[1] Monograph of the Fossil Merostomata of Great Britain. Memoirs of the Palæontographical Society. London, 1866.

consider that the eyes of Arthropoda [1] generally are not developed upon a separate segment. I have also endeavored to show [2] that in the Insects the compound eyes are developed in the first or antennary segment.

Examining the embryology of other Branchiopoda, we find that the Cladocera (Daphnia, according to Dohrn's researches,[3] and Leptodora),[4] and the Phyllopoda (Limnadia),[5] have the eyes developed on the same segment, as also Apus; this may be plainly seen by reference to Zaddach's figures.[6] In *Artemia salina*[7] they arise as in Apus, on the first antennal ring, and afterwards become pedunculated. In Nebalia the figures of Mecznikow show that the eyes are developed on the cephalic plates, as in the Libellulidæ, which form the tergite of the first antennary ring. In the Decapoda, Dohrn (l. c.) has shown that their position is the same, as shown in the embryo of *Cuma Goodsiri*.

As seen also in the zoëæ of the higher Decapoda, these organs arise on the first antennary ring. Dohrn's figures of *Praniza maxillaris* show the same position of the eyes, and this seems to hold good for all the Tetradecapoda, a view which Rathke's [8] figures of Bopyrus and Ligia confirm. From this evidence we seem justified in considering that the first segment of the head in Arthropoda is antennal. We must, then (assuming, unless future discoveries reveal an additional pair, that there are but five segments in the head of the Eurypterida, each bearing a pair of appendages [9]), regard the region bearing these members and two pairs of eyes, simple and compound, as a cephalothorax comparable with that of Limulus, the thoracic segments being potential; but with one segment less, that bearing the first pair of maxillipedes. This difference in the number of segments composing this region we would not consider as of much consequence, in a group (Branchiopoda) in which the number of body segments is so inconstant. Mr. Woodward's "eighth cephalic segment," bearing the "operculum," or "thoracic plate," and which he himself regards as the homologue of the first pair of lamellate feet in Limulus, is, in our view, beyond question the first segment of the abdomen of the Eurypteridæ. This is succeeded by twelve segments, counting the telson (as what we now know of the embryology of Limulus gives us a right to do) as one. Thus, from the facts which Mr. Woodward affords us, we make eighteen instead of twenty-one segments, four of his segments being hypothetical.[10] Turning now to Professor Hall's restoration of Eurypterus (Palæontology of New York, vol. III, 1859), and counting the number of segments in the cephalothorax and abdomen (which I was careful not to do before writing the preceding sentence, in order to test the correctness of my own observations), I find five segments in the cephalothorax, bearing the same number of appendages, and thirteen well defined segments in the abdomen, making eighteen in all, the

[1] The term Arthropoda is used simply for convenience, as I am disposed to regard the division of Articulata into Arthropoda and Worms (Vermes) as a somewhat artificial one.

[2] Embryological studies on Diplax, Perithemis, and the Thysanurous genus Isotoma. Memoirs Peabody Academy of Science, Salem, 1871, p. 21.

[3] Untersuchungen ueber Bau und Entwickelung der Arthropoden. Leipzic, 1870.

[4] See Bidrag til Cladocerernes Forplantnings-historie. Ved P. E. Müller. Schiödte's Naturh. Tidsskrift. 1868, p. 295.

[5] Observations sur la Génération et le Développement de la Limnadia Hermanni. Par M. Lereboullet, Annales des Sc. Nat., Ser. 5me, vol. v, p. 283. 1866.

[6] De Apodis cancriformis, etc. 1831.

[7] Histoire d'Artemia salina, etc. Annales des Sc. Nat. Ser. 2me, Vol. III, pp. 225, 840.

[8] Zur Morphologie. Reisebemerkungen aus Taurien. 1837.

[9] Huxley's theory, that the antennules, or first antennæ of Pterygotus are aborted, appears to me from the reasons suggested above to be scarcely tenable, having no apparent foundation in the structure of the Branchiopods.

[10] I can make but two segments out of Mr. Woodward's VII, VIII, IX, (see his plate VIII,) *i. e.*, the first and second abdominal plates, being his "operculum" and the gill-bearing segment almost concealed by it.

same as in Pterygotus. The line between Mr. Woodward's thorax and abdomen of the Eurypteridæ seems to me to be a purely imaginary one. So also in Limulus has Mr. Woodward drawn an imaginary line across the abdomen. (See Quart. Journ. Geol. Soc., London, Feb., 1867, pl. II., fig. 1.) But that I may not seem to do injustice to his views, I quote his account of the homologies of Limulus below.[1]

So far, then, as the external form of this region of the body is concerned, with its appendages, it forms in Limulus a true head, consisting of six segments, each bearing a pair of limbs, the antennary segment on the tergal surface a pair of simple eyes, and the third or mandibular segment a pair of compound eyes. On examining the arrangement of the viscera, however, we find that this head contains organs that in other Branchiopoda and in the Malacostraca[2] are lodged in the thoracic region. We may consider the thorax in Limulus as potential, so far as regards the presence of external segments, but real when we regard the disposition of the internal organs, so that we may feel justified in applying the convenient term cephalothorax to the anterior division of the body, just as we would call the same region in the zoëa a cephalothorax, before the thoracic segments are developed. By a reference to fig. 27, on plate V, we see that this cephalothorax contains the stomach, and a considerable portion of the intestine, and the liver, which opens into the intestine near the middle of the cephalothorax, sending but a single pair of biliary tubes

[1] "In Limulus the head is composed of a broad buckler, having the larval and compound eyes upon its superior or convex surface, and the mouth, surrounded by six pairs of chelate appendages, placed beneath the head-shield. The first pair of appendages is placed in front of, and the four succeeding pairs are posterior to, the mouth. These latter are furnished with spinous gnathites, the most posterior pair serving as *maxillæ*. Next follows the *operculum*, or thoracic plate, which is attached to the posterior margin of the head, and bears upon its inner and upper surface the reproductive organs or ovaries. . . . . The anterior portion here spoken of as the head has always been regarded as representing the cephalothorax, and the posterior portion as the abdomen." [Savigny and Milne Edwards, (though in Todd's Cyclopædia, art. Crustacea, p. 772, Expl. fig. 111, he calls the base of the abdomen thorax,) and Van der Hoeven, together with several other authors, down to the present time, have regarded the anterior division of the body as the head, and the posterior as the abdomen. On the other hand, Latreille, in his last work in the second edition of the Regne Animal, says, in a foot note, vol. I, 1829, p. 187: "Les deux pieds antérieurs pourraient représenter les mandibules des décapodes; les quatre suivants, leurs machoires, et les dix derniers, leurs pieds-mâchoires; ceux du second bouclier répondraient aux pieds thoraciques"; while Professor Dana's views (Crustacea, Exp. Exp., 1852) as to the homologies of Limulus, are as follows: "In Limulus the body consists of three segments, and they may be compared to the segments in Caligus. The anterior segment bears six pairs of members; the *first* appears to correspond to the second pair of antennæ (or third normal segment), the *second*, *third*, *fourth*, *fifth* and *sixth*, to the mandibles and the four following pairs of members (or the fourth to the eighth normal segments inclusive). In the Caligus the last pair here referred to is natatory, and the carapax is divided just anterior to it, instead of posterior. The second segment of the body, which we consider as a continuation of the cephalothorax, and not abdominal, bears *six* pairs of foliaceous organs, analogous to the foliaceous appendages of the posterior part of the thorax in certain Caligidæ, in some of which one or two pairs of legs are combined into a hard, thin plate, like an apron. These six pairs make up exactly the normal number of cephalothorax segments,—*fourteen*. . . . . The abdomen, according to this view, is confined to the last or third segment." He remarks in another place, Amer. Journ. Sc., vol. XXXVI. Nov. 1863, p. 346, "The joint across the carapax of the Limulus corresponds in position to a suture or imperfect articulation in the carapax of the Caligi, etc."] "This latter," continues Mr. Woodward, "I propose to call the thorax (in part), and to give my reasons for doing so as we proceed. . . . . If the head in Limulus be composed of the cephalothorax, and the posterior portion be the abdomen, then it follows that the opercular plate is thoracic, and the succeeding branchial plates are abdominal, thus differing widely from the fossil forms, in which the head is simply the head, with one thoracic segment added to it, bearing the opercular plate; the branchiæ are thoracic, and the abdomen is entirely destitute of appendages. Let it be granted, however, that the head in Limulus represents the entire cephalothorax, and the posterior portion the abdomen; if specimens can be shown having a 'post-abdominal' series of segments, I think it will be conceded by all carcinologists that in Limulus the abdomen is rudimentary, as is the case in Cyclops, Daphnia, Lernæa, etc., and in the Brachyurous Decapods."

[2] The terms Malacostraca and Entomostraca we only use for convenience, believing them to be useful but artificial categories; as we see the Decapoda graduating through the Phyllopodous Nebalia, etc., into the Branchiopoda, and the latter (through the Cladocera) into the Ostracodes, Copepoda, and more remotely into the Cirripedia.

into the abdomen. The anterior half of the dorsal vessel, with two pairs of arteries and two pairs of valvular openings, is situated in this cephalothorax. Lastly, the genital openings in both sexes are situated on the first pair of abdominal lamellate appendages, the testes and ovaries lying wholly in the cephalothorax; the ovaries, when distended with eggs, filling up the front of the cephalothoracic shield.

The posterior region of the body, which is evidently the abdomen, consists of nine segments, the long spine-like telson forming the ninth, as plainly seen in the embryo. As an important argument that this portion is a true abdomen, we have seen that the increase in the number of body-segments occurs in this region; the new segments, and the new appendages joined to them, are interpolated between the third segment (that bearing the third pair of lamellate feet) and the telson. We have before called attention to the fact that in the worms, the Myriapoda (Iulus), and in the hexapodous insects, the increase in the number of segments of the body usually takes place between the penultimate and last segments, and this is probably the rule in nearly all the Articulates. (The Trilobites, according to Barrande's researches, apparently form an exception, the thoracic segments being added between the head and the pygidium, the latter apparently consisting of several segments; but this mode of increase may be due to the peculiar metamorphosis of these Crustacea, the larva being born with the abdomen formed much as in adult life, and the thoracic segments being added at subsequent moults. It should also be borne in mind that the zoëæ of the Decapoda also add five thoracic segments at the time of the first moult.) The abdominal cavity of Limulus is comparatively small, this region being very thin, and, except the termination of the dorsal vessel and intestine, being mainly filled with the muscles attached to the lamellate feet. The feet are truly branchiopodous, combining the function of respiration with that of swimming, as in the Phyllopoda.

There are, then, in Limulus no thoracic feet, comparable with those of the Decapoda and the Tetradecapoda, and the thoracic region (as much of it as exists) is merged with the head, in fact never becoming differentiated from the head proper. Thus we have in Limulus a crustacean with the body divided into two regions; a cephalothorax (the thorax being potential, when viewed externally, with no appendages or segments to indicate its existence) and a nine-jointed abdomen.

This disposition of the body segments is paralleled by the structure of the zoëa or larva of the Decapoda.

Turning now to the opinions of different authors as to the affinity of the Eurypteridæ to Limulus, and also to the Trilobites, given in Hall's Palæontology of New York, III. and Woodward's bibliography in his admirable monograph of the Merostomata, we find that W. Martin, in 1809, "gave a figure and short description of a Limulus crustacean from the coal measures, which he included with the Trilobita." In 1825, Dr. J. E. DeKay described and figured the first American species known (*Eurypterus remipes*), and referred it to the class Crustacea, and to the order Branchiopoda, so that to him belongs the credit of first correctly estimating the true affinities of this animal. In 1844, Professor Agassiz remarked of Pterygotus: "I am rather inclined to believe that this singular animal will become the type of a family intermediate between the *Trilobites* and the *Entomostracans*, in which, perhaps, the *Eurypteri* and the *Eidotheæ* will some day be included." In 1846, Burmeister "makes the *Eurypteridæ* the first family of the tribe *Palæadæ*." In 1851, Dr. Ferdinand

Roemer "suggested the affinity of Eurypterus with Limulus; pointing out, however, the great difference in the feet, etc.

In 1849, and again in 1854, McCoy united the Limulidæ with the Eurypteridæ in the tribe Pœcilopoda of the order Entomostraca. In 1856, Huxley compared Himantopterus (Pterygotus) to the zoëæ of the Decapods, remarking that "The nearest approach to Himantopterus which could be constructed out of the elements afforded by existing Crustacea, would be produced by superinducing, upon the general form of a Cumoid Crustacean, such a modification of the appendages as we find among the zoëaform Macruran larvæ." In 1857, in his "Lectures on Natural History," he remarks again: "I conceive, therefore, that the *Eurypterida* must form a group by themselves, which are best understood by combining together organic peculiarities, at present found only in the *Copepoda*, the *Xiphosura*, the *Diastylidæ*, and the larvæ of *Podophthalmia*."

In 1859, Prof. James Hall, in the "Palæontology of New York, III," "containing," according to Mr. Salter, "the fullest material for the illustration of this genus" (Eurypterus), discussed more fully than any one else had done the close relation of Eurypterus to Limulus, having shown satisfactorily the homologies of the "anomalous plates and processes[1] about the position of which Prof. Huxley and myself [Salter] were compelled to guess," *i.e.*, that they are homologous with the first pair of abdominal swimming respiratory feet of Limulus. "All this was as satisfactorily made out by" a Russian naturalist, Nieszkowski [in the same year]. "We [Salter] had also arrived at the same conclusion before Nieszkowski's admirable paper had reached us."

Professor Hall remarks that he is not prepared to agree with Huxley in the opinion that this form and Pterygotus are related to Cuma and Mysis, and then says, "As my examinations have progressed, and the parts now shown have gradually been brought out in their true relations by the study of a large number of specimens, many structural analogies with Limulus have been observed. At the same time, both in the form of the feet and in the jointed body, the great dissimilarity with Limulus is apparent; but I am not prepared to maintain that these external differences are of ordinal importance." He then adds in a foot note that Mr. Morris, in his "Catalogue of British Fossils," has arranged the Eurypteridæ, including Eurypterus and Pterygotus, as a family following Limulidæ, under the same order. He then cites Professor Agassiz's opinion after an inspection of his specimens, as follows: "This preëminent naturalist has given his opinion most unequivocally that the Eurypteri are closely related to Limulus, belonging even to the same order. He regards the antennal system as entirely absent. The organs of locomotion all belong to the cephalic region; and while externally they perform the functions of feet, they are at their bases organs of manducation. The central organ, indicated as a locomotive appendage, and attached to the lower side of the first segment, Professor Agassiz regards as similar to the appendage attached to the membranaceous feet behind the swimming feet of Limulus, and instead of being double, as anchylosed, as in young Limulus. Since my comparisons, during investigations of these fossils, had been made almost entirely with Limulus, I am prepared to appreciate these views of Professor Agassiz."

[1] Mr. Woodward, following Prof. Huxley, calls this the "thoracic plate, or operculum"; in reality it is the first pair of abdominal lamellate feet, and Hall's discovery is of the highest value in thus establishing the close affinity of Eurypterus to Limulus, and decides, it seems to us, beyond any reasonable doubt, that the two forms should be placed in the same group, whether we call it suborder or order.

Hall's direct homology (Palæontology, N. Y., III, pp. 298, 299) of the first pair of abdominal feet of Eurypterus with those of Limulus, also his discovery of the ocelli and the true number of joints in the fifth pair of feet of Eurypterus (thus demonstrating more fully than ever before the close affinity of these two groups, at first sight so unlike), and Huxley's comparison of Eurypterus to the zoëa of the Decapoda, are perhaps the two most brilliant discoveries we have to record in the history of our knowledge of the Merostomata, since the original discovery of the true affinities of Eurypterus by DeKay in 1825.

But while Professor Huxley has made such an apt comparison of Pterygotus to a zoëa, he seems to have adopted certain taxonomic views directly contrary to Prof. Hall's, and which seem to us quite untenable. Mr. Woodward[1] quotes him as saying in 1859 ("On the Anatomy and Affinities of the Genus Pterygotus, Memoirs of the Geological Survey of Great Britain, Monograph I"), "The Pœciloptera [*i. e.*, Limulidæ] are, I believe, the only Crustacea which possess antennary organs like those of Pterygotus, and, like them, have the gnathites converted into locomotive organs, want the appendages to the sixth abdominal somite, and present on some parts of the body a remotely similar sculpture. In this order, however, we find but a small labrum, a rudimentary metastoma, a very differently constructed body, and a larger number of appendages, both thoracic and abdominal—characters which effectually preclude the association of the extinct Crustacea under discussion with this type." He adds in a foot note, "If the abdominal somites of the carboniferous Bellinurus, etc., were really free, they would present a certain approximation to the Pterygotus. Indeed, the evidence that these carboniferous Crustacea were true Pœcilopoda is, to my mind, any thing but conclusive." That such an acute mind as Professor Huxley's could separate (if we understand him aright) Bellinurus from Limulus seems strange. The characters he enumerates as distinguishing the Pœcilopoda from other Crustacea are, without an exception, of secondary importance. Apus has one pair of limbs serving at the base as chewing organs (gnathites, according to Huxley), and at the extremity as locomotive organs. The size of the labrum, or hypostoma, varies greatly in the Branchiopoda, and especially the Phyllopoda. The body is very differently constructed in different genera of the Phyllopoda, and the number of "appendages, both thoracic and abdominal," varies indefinitely in the Branchiopoda.

Woodward, in his splendid "Monograph of the fossil Merostomata (1866)," adopts "the advanced ideas of Agassiz, McCoy, Hall, Huxley, Salter and others," and shows the close relationship of the Eurypteridæ to the Limulidæ, placing them as suborders (*Eurypterida* Huxley, and *Xiphosura* Gronovan) of the order Merostomata of Dana. To his work we are mostly indebted for a full summary of our present knowledge of the fossil Merostomata, and I have made frequent use of it in the preparation of this paper.

The Rev. Dr. Lockwood, "American Naturalist," IV, p. 269, compares certain features in the larval stage of Limulus, with Pterygotus and Eurypterus.

The larva of Limulus zoëaform. Fritz Müller, in his suggestive work "Für Darwin," thus enumerates the most important peculiarities which distinguish the zoëa, or larva, from the adult decapodous animal: "The middle body, with its appendages, those five pairs of feet to which these animals owe their name of Decapoda, is either entirely wanting, or scarcely indicated. The abdomen and tail are destitute of appendages, and the latter con-

[1] "On some Points in the Structure of the Xiphosura, having reference to their Relationship with the Eurypteridæ." (From the Quarterly Journal of the Geological Society, Feb., 1867, p. 28.)

sists of a single piece.[1] The mandibles, as in the Insecta, have no palpi. The maxillipedes, of which the third pair is often still wanting, are not yet brought into the service of the mouth, but appear in the form of biramose natatory feet. Branchiæ are wanting, or when their first rudiments may be detected as small verruciform prominences, these are dense cell-masses, through which the blood does not yet flow, and which, therefore, have nothing to do with respiration. Fig. 29, (from Müller) is an example of a zoëa, being the "young zoëa" of Penæus. As in the zoëa, the body of the larval Limulus consists of a head and abdomen, the thoracic segments not being at this or at any subsequent stage developed; for in the zoëa before the first moult, the thorax is potential, the rudiments of five thoracic segments being seen just behind the posterior pair of deciduous maxillipedes. The head is comparable to the cephalic shield of Apus; like it, bearing a pair of simple and compound eyes, but greatly differing from it in being united with the body along the lower edge, instead of being free, as in the Phyllopoda. In the zoëa stage of Decapoda, however, the eyes are not at first pedunculated, but sunken in the carapace. The six appendages of Limulus are cephalic, the first two pairs being probably the homologues of the first and second pair of antennæ[2] of the zoëa of Decapoda, and the Phyllopoda (Apodidæ and Branchipodidæ), while the third pair probably represent the mandibles, the fourth pair the first maxillæ, and the last two pairs the maxillipedes (perhaps the fifth pair represent the second maxillæ of Apus, and consequently the sixth pair alone represent the maxillipedes).[3] It should be noticed that these appendages are all situated in front of the metastoma, which in Limulus has been homologized with the languette or "labium" of the Decapoda, by Milne Edwards.[4]

Fig. 29.

[1] I have found an exception to this in the zoëa of *Alpheus minus* Say, observed in January at Key West, Florida, in which, before it is hatched, there are five pairs of short biramose abdominal feet. The absence of abdominal appendages is not, therefore, an essential character.

[2] At first I was disposed to consider the first pair of appendages of Limulus as mandibles, regarding the antennæ as wanting. (See "American Naturalist," IV., Feb., 1871, p. 751.) Fabricius (1783) called them mandibles, considering Limulus as wanting antennæ. Savigny (1816) regarded Limulus as wanting, not only the two pairs of antennæ, but also the four succeeding pairs of limbs. He calls the first pair of actual appendages "mandibules succédanées," and compares them with the third pair of maxillipedes of Apus. Van der Hoeven (1838) calls them feet, while Latreille at first (Hist. Nat. des Crust. Ins., 18) followed Fabricius in regarding them as mandibles, and afterwards, as Van der Hoeven states, he doubtfully considered them as antennæ, in the first edition of the "Regne Animal." But in his "Familles Naturelles" (1825) and the second edition of the "Regne Animal," (1829) he considers them as representing the antennæ of other Crustacea, though usually in referring to them he calls them feet (pattes).

[3] I find that Mr. Woodward has applied the same terms to the appendages (see his work on the British Fossil Merostomata). The fact that all the appendages of the nauplius of the Cirripedia are situated in front of this prolabium, and that its position is identical with that of Limulus, is another proof that the ambulatory appendages of Limulus should be all considered as cephalic.

[4] Latreille (Regne Animal, 2d Edition, 1829) remarks of this double organ, "Les deux pièces situées dans l'entre-deux de ces pattes, que M. Savigny considéré comme une languette ne me paraissent être que deux lobes maxillaires de ces organes, mais detachés au libres." p. 186. But we have shown that this metastoma arises as two tubercles long after the last pair of cephalothoracic feet are developed, being entirely disconnected from, and forming no part of them. This organ seems to be homologous with the immense bifid organ of the nauplii of certain Cirripedia (especially Tetraclita, as figured by Fritz Müller), which nearly equals the abdominal spine in size.

In the freshly hatched zoëa the body is divided into two regions: the cephalothorax (but at first, as in Limulus, with no trace of thoracic segments or thoracic appendages, the two pairs of large feet being deciduous maxillipedes, the thorax not being yet differentiated), and a five to seven-jointed abdomen. The size of the cephalothorax, as compared with the abdomen, varies greatly, as is well known, in the different forms of zoëæ, some forms resembling Eurypterus in the small cephalothorax. After the first moult five pairs of rudimentary thoracic limbs arise at the junction of the cephalothorax with the abdomen. We feel justified, then, in considering the larva of Limulus as a zoëa.

But while we have endeavored to show that the young of Limulus is essentially zoëæform, we would not overlook the great differences between the two forms, seen especially in the elongated body, the form of the cephalothoracic limbs, and the presence and peculiar form of the abdominal appendages of the decapodous zoëa. The two pairs of antennæ (though they are locomotive in function) of zoëa, are in Limulus replaced by ambulatory feet, ending in claws; and the two pairs of biramose deciduous maxillipedes of the zoëa are replaced by feet identical in form with those in front. That there are a greater number of cephalothoracic and abdominal appendages respectively in the zoëa of Limulus than that of the Decapoda is not of primary importance. When we examine the less essential characters of Limulus we find, on comparison with certain forms of zoëæ, (such as Fritz Müller's figure of the zoëa of a Penæus, Für Darwin, fig. 32) with its large carapace and small abdomen, also Milne Edward's figure of *Erichthus aculeatus*, with its large carapace and short, broad abdomen, with five pairs of swimming feet, many points of resemblance. The spines on the carapace of Limulus are also comparable with those of certain zoëæ.

The Merostomata zoëæform. As our Limulus at birth only essentially differs from the adult by having three instead of six pairs of abdominal feet, and no caudal spine (though existing in a rudimentary state), the question resolves itself into a comparison of the adult Limulus with the young of the Decapoda. In some respects there is a certain likeness between the higher Branchiopoda (the Phyllopoda especially) and the zoëa of a Decapod. This consists in the fact that all the limbs between the mouth and the abdomen, or genital openings, are but slightly differentiated—in short, they are all maxillipedes, and there is an absence of the five pairs of special locomotive limbs, to which the young Decapoda owe their name, appended to a thoracic region (pereion), which distinguishes the zoëa, as Müller well says. In Branchipus, Apus and Nebalia, with their two pairs of antennæ, we have the nearest approach to a zoëa. The Phyllopoda have bi- or tri-ramose abdominal appendages, and while no zoëa has been hitherto known to possess them, the zoëa of *Alpheus minus* Say has five well developed pairs. The telson, as in the Merostomata and certain Phyllopoda (Apus and Limnadia) "consists of a single piece." Prof. Huxley[1] has compared Pterygotus (Himantopterus) to the Stomapoda and zoëa forms.

While the likeness of Limulus to a zoëa may seem very remote, we would call attention to certain peculiar decapodous larvæ, discovered and figured by Dr. A. Dohrn, which bear a certain resemblance to the king crab. Such are the "zoëa of a Penæus(?)" represented at fig. 54, pl. xxx, of Siebold and Kölliker's Zeitschrift für Wissens. Zoologie" (Bd. 21, Heft.

[1] "The nearest approach to Himantopterus which could be constructed out of the elements afforded by existing Crustacea, then, would be produced by superinducing upon the general form of a Cumoid crustacean such a modification of the appendages as we find among the zoëæform Macruran larvæ." Observations on the Structure and Affinities of Himantopterus, Quarterly Journal Geological Society of London, xii., 1856, p. 37.

3, 1871), and the "unknown larva," p. 62. But when we compare the Eurypterida with the normal larvæ of Decapods, there is a general likeness, which, as Huxley has clearly pointed out, is of peculiar significance. This is seen in the small cephalothorax, with the compound eyes sunken in the head, as in some zoëæ, and the long, narrow, equally-jointed abdomen, with its spine-like or spatulate telson. Here we have, if we are not mistaken, prophetic forms, which peopled the palæozoic seas, and announced the coming of a higher type of crustacean life. The gigantic Eurypterida are to the Decapoda of the present times what the Pythonomorpha and Ichthyosauria and Plesiosauria are to their modern representatives; and whether or not the Decapoda be the direct lineal descendants of the Eurypteridæ, they are, at least when in the early stages of growth, heirs of some of their peculiar features, though they may claim a distinct line of descent from the ancestors of a hypothetical nauplius, with new and higher characters superadded.

Comparison of Limulus with the Trilobites. Let us now compare the larva of Limulus with those of the Trilobites. Barrande, in his great work on the Silurian Fauna of Bohemia,[1] has been the first to describe the recently hatched larvæ of certain Trilobites, at least before the young had moulted, and has presented us with an array of facts, that are of the greatest use in our comparison.

A glance at our figures 12 and 32, will at once suggest the form of the Trilobites, as also of the Xiphosurian genera Bellinurus, Prestwichia, and Euproöps, (see cuts 30, 31, *Prestwichia rotundatus*, Prestw., *Euproöps Danæ*, Meek and Worthen[2]) from the Carboniferous formation. The latter are evidently forms which may be compared with the larva of Limulus, from the prominence of the cardiac lobe, the distinctness of the abdominal segments, and the short spine, while the form of the carapace is still more trilobitic in the posterior prolongations of the outer edge. These forms are alluded to here as indicating in Carboniferous times the existence of intermediate types between the Merostomata and Trilobites.

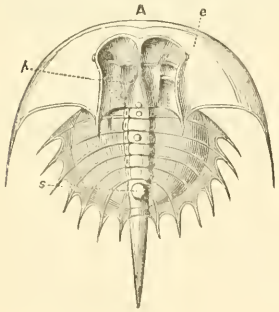


Fig. 30.

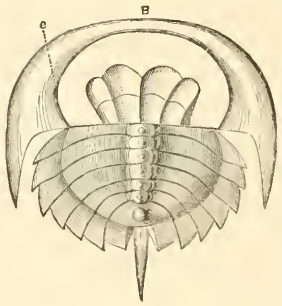


Fig. 31.

The resemblance of the ripe embryo, and in a less degree, the larva of Limulus, to the Trilobites is seen in the very distinct trilobate character of the body — the cardiac lobe being very prominent,—and in the distinct segments of the abdomen. The resemblance is completed by the absence of the caudal spine of the adult Limulus. In comparing the larval forms of Limulus with those of the Trilobites, as described and figured by Barrande, we are struck by the close correspondence between them. We have endeavored to show that the larva of Limulus is to be compared with the zoëa of the Malacostraca. We should not intro-

[1] Système Silurien du Centre de la Bohême. Par Joachim Barrande. 1ère Partie. Recherches Paleontologiques. Vol. I. Crustaces; Trilobites. 1852.

[2] I am indebted to the Illinois Geological Survey, through Professor Worthen, for the use of these cuts.

duce the subject here, had not an eminent carcinologist, Mr. Spence Bate, remarked that "the young of Trilobites are of the nauplius form."[1] We would contend that while the larva of Limulus probably passes through a nauplius form early in the life of the embryo, at a little later period it appears with its cephalothorax divided into distinct segments bearing the full number of limbs, and with a nine-jointed abdomen, bearing three pairs of limbs and ending in a broad expansion. It remains in the egg state some time, and is hatched without undergoing the complicated metamorphoses of the Phyllopoda, and other Crustacea born with a true nauplius form, such as is presented by that of Penæus.

Compare with our figure of the recently hatched Limulus (pl. IV, fig. 13, 13 *a*, 13 *b*, 13 *c*, 13 *d*, and 32), Barrande's larva of *Trinucleus ornatus* Sternb. (fig. 33, and natural size; enlarged from Barrande's figure for the sake of easier comparison). One will see at a glance

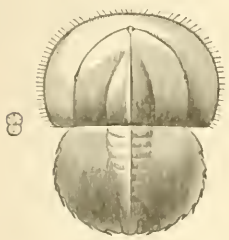


Fig 32.

Fig. 33.

Fig. 34.

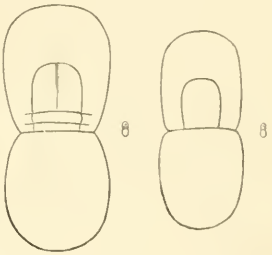


Fig. 35.

that the young Trilobite, born without any "thoracic" segments, and with the cephalothorax articulated with the abdomen, closely resembles the young Limulus. In both, as in no other young Crustacea, the body, especially the cephalothorax, is trilobitic. In Limulus no new segments are added after birth; in the Trilobites the numerous thoracic segments are added during successive moults, as Barrande's beautiful plates so clearly show. The Trilobites thus pass through a well marked metamorphosis, though by no means so remarkable as that of the Decapodous Crustacea and the Phyllopoda. Again, the resemblance is seen in the larval *Agnostus nudus* Beyr. (fig. 35, also enlarged; and natural size; the left hand figure represents the adult), where the body consists, as in Trinucleus, of the cephalothorax and abdomen (pygidium), the two thoracic segments being added at a subsequent moult. *Agnostus bibullatus* Barr., *A. rex* Barr., and *A. integer* Beyr., have similar larval forms.

In the larva of *Sao hirsuta* Barr. (fig. 34, natural size, and enlarged from Barrande's figure) neither the "thorax" nor abdomen are differentiated, and the body is orbicular, but with the cardiac region well developed, and with indications of segments which are in the next moult abdominal in their position, indicating that the larva of this Trilobite was not much unlike those of the others enumerated above. We feel justified, then, in considering the larval Trilobite as a subzoëa, and would suggest that at this period it was perhaps provided with cephalothoracic appendages, while broad lamellate, swimming and respiratory feet were very probably attached to the pygidium.

Judging from Barrande's descriptions of the eggs of the Trilobites, they must have

[1] See Facts for Darwin, p. 96.

resembled those of Limulus, and like them have been surrounded by a tough, thick chorion, as Barrande supposes must have been the case. He states that these eggs occurred in the form of black spherules, some two-thirds, and others four or six millimetres in diameter,[1] mingled in the same beds with fragments of Trilobites. After giving in detail his reasons for supposing them to be eggs, he says, "as regards their size, the spheroids in question could have been the eggs of Trilobites, because the smaller ones have exactly the same diameter as the first age of *Sao hirsuta*, namely: two-thirds of a mm. The greater diameter of the other spheroids (two to five mm.) is in accordance with the size of the Trilobites among which they have been found, as *Acidaspis Verneuili* and *Cheirurus Quenstedti*."

As regards the close resemblances between the adult Limulus and Trilobites, the facts presented by Mr. Billings[2] have enabled that able palæontologist to make the comparison between the forms of the two groups a very close one. His discovery of a specimen of *Asaphus platycephalus* preserved on the under side, so as to present indications of what he, with some reserve, considers as eight pairs of five-jointed legs, instead of the hypothetical phyllopodous feet of Burmeister and other authors, if it should be confirmed, at once places them in the closest relation with the Merostomata.

The specimen here alluded to was submitted to the members of the Geological Society of London, and Mr. H. Woodward pronounced in favor of Mr. Billings's views. On the other hand, Prof. J. D. Dana, to whom Mr. Billings also sent the specimen for inspection, concludes (Amer. Journ. Sc., May, 1871, p. 320) with Messrs. Verrill and Smith, that the "organs are not legs, but the semi-calcified arches in the membrane of the ventral surface to which the foliaceous appendages, or legs, were attached. Just such arches exist in the

[1] The eggs of Limulus are a little less than two millimetres in diameter.

[2] Mr. Billings thus describes the specimen which good fortune had placed in such good hands, and of which he read a short notice before the Natural History Society of Montreal, in 1864.

"This specimen was collected in the Trenton Limestone, at the City of Ottawa, about ten years ago. When discovered it was lying flat upon a thin slab of limestone, and well preserved with the exception of the eyes, which seem to have been forced inwards by pressure from above. It was also divided into two pieces by a fissure which extended diagonally across, from the first segment of the thorax on the left side to the fifth segment on the right.

"It remained in the Museum for several years without attracting particular attention, until one day, observing that the part in front of the fissure was somewhat loosely attached, I removed it, and was surprised at finding, on the under side, not only the hypostoma in place but also what appeared to be some of the legs of the animal. As the part behind the fissure was more firmly attached to the stone, I had it cut across just behind the eighth segment by the lapidary of the Survey. The remainder of the thorax was then easily split off. The pygidium came off with difficulty, and in two pieces. All the pieces were then fastened together, and we thus obtained two specimens, one of which shows the under side of the trilobite and the other its impression on the stone.

"On the under side a broad, shallow groove extends from the space between the two lobes of the hypostoma, where we must suppose the mouth to be situated, backwards along the median line to the pygidium. This corresponds in position to the sternum of the ordinary crustacea. The legs are arranged in eight pairs, the bases of each pair being situated exactly under one of the eight segments of the thorax, and at the sides of the sternal groove.

"The legs of the first pair are better preserved than the others. They curve forwards, and can be traced to a point nearly under the outer edge of the eye, or rather between the eye and the outside of the head. The other seven pairs follow at the average distance of two and a half lines from each other. The eight pairs thus occupy about twenty lines of the length of the ventral surface. This is exactly the length of the thorax, measured on the upper side. This trilobite has always eight segments in the thorax, and there is thus on the under side one pair of appendages to each segment. Although some of them are very imperfect, and the portions that remain are somewhat displaced, with a little study of the specimen it can be seen that they all curve forwards, and are thus, most probably, ambulatory rather than natatory legs.

"There appear to be several joints in each of those appendages, but the exact number cannot be made out. On the left side, the first four legs show very clearly that there are at least two, one at five lines from the side of the groove, and another about three lines further out. The position of each of these is indicated by a small protuberance (Pl. 1, fig. 1, *n*). On the right side the preserved portions of the legs are longer, and thus indicate a greater number of articu-

ventral surface of the abdomen of the Macrura, and to them the abdominal appendages are articulated. This conclusion is sustained by the observation that in one part of the venter three consecutive parallel arches are distinctly connected by the intervening outer membrane of the venter, showing that the arches were plainly *in the membrane*, as only a calcified portion of it, and were not members moving free above it." Mr. H. Woodward (Geological Magazine, July, 1871, p. 289), in endeavoring to show that the semicalcified arches "are truly legs, reproduces Billings's figure of the Asaphus, and also figures the under side of *Nephrops Norvegicus* to compare it with," and concludes that the appendages of the Trilobites "were attached along either side of a median line, and that the lateral extremities were free." He also thinks that if the appendages of Trilobites were soft foliaceous gill-feet, "then the presence of strong sternal arches would have been needless; on the other hand, if we accept Burmeister's decision, that such hardened sternal arches *must accompany* horny or calcareous feet, then it follows as a matter of course that — accepting Prof. Dana's interpretation — Asaphus must have had such hard appendages, which the very presence of semicalcified arches in the ventral integument proves to have existed."

Though disposed to regard these processes figured by Mr. Billings as feet, still the proof is unsatisfactory; but reasoning on general grounds from the structure of the rest of the body, the heavy, thickened, dorsal side of the body, the rounded front of the head, and the form of the pygidium, the Trilobites probably had habits similar to those of Limulus, and consequently they must have had ambulatory feet, rather than phyllopodal feet, attached to the middle segments of the body. And I find that Dr. Dohrn entertains the same view. In his suggestive "Geschichte des Krebsstammes" (Jenaischen Zeitschrift,

lations, although they cannot be distinctly seen. I think that each leg consisted of at least four or five segments.

"On the pygidium there are three small ovate tubercles, arranged in a line, that seem to be organic (fig. 1, *d*), and, if they are so, they are, perhaps, the processes to which respiratory feet were attached.

"The length of the specimen is four and a half inches, and the width two and a half. On a side view the height of the head just behind the eyes is nine lines, and at the middle of the thorax about seven lines. The depth of the internal cavity at the back part of the head is seven lines, and at the last segment of the thorax four lines. The plane in which the legs are situated is, therefore, not so low down as the extremities of the pleuræ. The visceral cavity is thus about one-third less than the whole bulk of the animal.

"The above is all that I desire to say at present concerning this remarkable specimen."

Mr. Billings then proceeds to homologize the other parts with Limulus. He says:—

"The evidence afforded by the specimen above described, and others of which I have made sections, proves that in the genus *Asaphus* the under side was not flat, but somewhat concave. In the head, on each side of the mouth, there was a cavity like that which occurs in the existing king crab—*Limulus Polyphemus*. The position of these cavities is at C, C, in Pl. 1, fig. 1. They are partially filled up in the specimen, but I have ascertained their depth to be about five lines in another individual of the same size. The ends of the pleuræ projected downwards a short distance below the level of the sternum. The pygidium was also concave at the sides, with a portion along the middle, holding the intestine, convex. This structure can be seen, in part, by examining the slab from which the specimen above noticed was split. Portions of the lower margins of the head and tail, and the extremities of some of the pleuræ, remain sticking in the stone. It can also be proved by polished sections through the head and tail of any well preserved specimen. Such sections usually show that a portion of the crust, called the 'doublure,' by Barrande, all round the margin, is folded under and reflected upwards, ending in a free thin edge. (Pl. 1, figs. 2, 3, 4.) The pleuræ have also a doublure, which extends upwards, nearly half way to the median lobe of the body. In consequence of this structure the extremities of the pleuræ are hollow, exactly like those of a lobster.

"In *Limulus* a similar doublure occurs, and we can see there that it is continuous with the thin membraneous crust which covers the under side of the body, and bears the limbs. Between the sternum of *Limulus*, with its load of ponderous legs, and the doublure, there is no connection all round except this fragile membrane. In consequence of this structure it often comes away with all its appendages, leaving nothing of the animal except its huge carapace, pygidium and telson. Specimens of this great crab in this condition are common in museums.

"In the genus *Asaphus*, and, no doubt in all other trilobites, the doublure is, as in these imperfect specimens of *Limulus*, only the remains of the integument which covered the under side and supported the sternum. These two genera, however, differ widely in other respects."

Bd. 6, Heft. 1, p. 131, 1870) he remarks: "The external structure teaches us before all, that we need seek for no swimmers in the Trilobites. Their body is broad and flat, very generally they are broadest before, at the head, a fact also certainly adverse to a rapid forward movement. We have already seen that a limitation of the power of swimming to the pleon (abdomen) decreases the longitudinal extension of the body; in the Trilobites the pleon, on the other hand, becomes a powerful, ponderous anal shield, the so-called pygidium, which either consists of numerous segments united together, or we find a whole series of smaller rings, but which do not in the least differ from the preceding segments of the middle body. It is also to be considered that the Trilobites chiefly lived at the bottom of the sea. Therefore they needed extremities by means of which they could walk. These extremities could not have been soft and yielding, since the Trilobites were truly heavy organisms. According to my opinion, we must conceive their extremities to have been like those of Limulus, but not longer than the carapace, or we should have detected traces of them. These extremities, as locomotive organs, were attached only to the cephalic shield — the rings of the body [posteriorly] carried most truly flat, leaf-like appendages, on whose inner side again, as in Limulus, numerous thin leaves formed the gills. I cannot consider that the Trilobites possessed extremities like the Phyllopods now living — with the power that they possess of rolling up their bodies, it seems the better opinion to compare their gills and the extremities carrying them to the gills of the existing Limulus." In considering the fact that no specimens of Trilobites have revealed any limbs from a dorsal view, it should be remembered that in none of the fossil Bellinuri, and even the Mesozoic Limuli, are there any indications of limbs projecting beyond the carapace; in death they are gathered up beneath the body, and those of the Trilobites, if they existed, probably were not long enough, as Dohrn says, to reach to the edge of the body when extended.

In view of the conflict of opinions as to the nature of the limbs of the Trilobites, it is to be hoped that the matter will not be suffered to rest here by palæontologists, even if the most unique and valuable specimens have to be sacrificed in making the requisite observations.

Adding to the homologies set forth by Mr. Billings, the trilobate character of the body in the young Limulus, the position and structure of the compound eyes, and the probability that, as Billings suggests, the abdomen of the Trilobites carried several pairs of phyllopodous or gill-like swimming feet, and we feel warranted from these, and the fact of their similarity in the larval forms, in placing the Merostomata and Trilobites near together in the subclass of Branchiopoda.

Through Barrande we learn that Beyrich has discovered the alimentary canal of *Trinucleus Goldfussi* Barr. The former states, "several specimens of our collections have also shown to us this canal which can be followed from the middle of the glabella up to the extremity of the axis, towards the posterior border of the pygidium. M. Beyrich has well observed that the canal in question is not found immediately under the test, but in the interior of the median lobe, of which it seemed to have formed the axis."

The internal organization and the habits of Limulus throw much light on the probable anatomy and habits of the Trilobites. The correspondence in the cardiac region of the two groups shows that their hearts and circulation were similar. The position of the eyes shows that the Trilobites probably had long and slender optic nerves, and indicates a general similarity in the nervous system. The genital organs of the Trilobites were

probably very similar to those of Limulus, as they could not have united sexually, and the eggs were probably laid in the sand or mud, and impregnated by the sperm cells of the male, floating free in the water. As previously stated, the female Limulus burrows beneath the sand or mud and leaves her eggs loose in the burrow, covered by a few inches of sand, etc. This is an exception to the usual mode of oviposition in the Crustacea. The only other exceptions known to us are the land crabs (Gecarcinus) of the West Indies, which go to the sea and leave their eggs in the water, and then go back to the land, and Squilla, which deposits her spawn in shoal water passages in the form of thin, round, yellow plates, according to Müller, but he adds that she remains by them aiding their development by driving a stream of water through the hole for her own respiration.

The muscular system of the Trilobites must have been highly organized, as in Limulus, as, like the latter, they probably lived by burrowing in the mud and sand, using the shovel-like expanse of the head in digging in the shallow palæozoic waters after worms and stationary soft-bodied invertebrates, so that we may be warranted in supposing that the alimentary canal was constructed on the type of that of Limulus, with its large, powerful gizzard and immense liver.

From these considerations, and the fact that the eggs have been found loose in the beds associated with remains of the animals themselves, we should suppose that the Trilobites lived in shallow water and near the shore, as Limulus does at the present day. Barrande supposed that they lived in deep water and swam on the surface of the sea, but the solid integument and flattened broad body would seem to have been sufficient to indicate that they frequented the bottom. Burmeister was probably more correct in supposing that they lived in shallow water.

Classification of the Branchiopoda. In his celebrated work on the "Organization of the Trilobites," Burmeister sagaciously concludes "that the Trilobites were a peculiar family of Crustacea, nearly allied to the existing Phyllopoda, approaching this latter family most nearly in its genus Branchipus, and forming a link connecting the Phyllopoda with the Pœcilopoda," but on account of the "varying numerical proportion of their thoracic rings," he thinks the relation is one of analogy and not of affinity, and that the Trilobites are equivalent to all the Entomostraca (*Aspidostraca*). With the ideas in the sentence quoted, our own review of the structure of the living Branchiopoda and the embryology of Limulus, and a comparison with the Trilobites, lead us to fully coincide; but we would go farther and include the Merostomata with the Branchiopoda, as together forming a division, (perhaps a subclass, equivalent to the Decapoda). Burmeister has demonstrated very clearly the close homology of the head of the Trilobites with that of the Phyllopoda, especially the structure and relations of the hypostoma and the frontal "doublure." The parts corresponding to the jaws and first pair of antenniform maxillipedes of the Phyllopods, are not preserved in the Trilobites. I would venture to predict from the structure of Limulus that we shall look in vain for antennæ in the Trilobites, *i. e.*, any articulated organs of sense arising in front of the mouth; while it is not improbable that a pair of antenniform maxillipedes, such as those of Apus, existed, together with pairs of jaws, like those of Branchipus and Apus, or ambulatory appendages, formed at the base like jaws, as in Limulus, on each side of the mouth.

The presence of a pair of maxillipedes was suggested by the observations of Mr. H.

Woodward,[1] who has "discovered upon the eroded upper surface of one of these, not only the hypostoma exposed to view, but also three pairs of appendages, and what he believes to be the palpus of one of the maxillæ."

Claus, in his "Grundzüge der Zoologie," 1868, thus characterizes the order Pœcilopoda: "Crustacea with a thick-shelled, arched cephalothorax, flat, shield-like abdomen, and a moveable caudal spine. Gills on the abdominal feet." This definition, now that we have indications that the Trilobites probably had thoracic ambulatory feet, and, in all probability, leaf-like appendages on the abdomen (pygidium), will apply about as well to Trilobites as to Limuli. We would suggest that while the differences between the two groups are very marked, that they are yet probably only ordinal, and that the two groups fall naturally into the subclass Branchiopoda,[2] which Claus (who considers it as an order) characterizes thus: "Crustacea of elongated, often clearly articulated bodies, for the most part with shield-shaped, cloak-like, or a bivalve duplication of the integument, with at least four pairs of leaf-like, foliaceous, swimming feet." This definition does not exclude the Merostomata, and probably, barring the number of pairs of abdominal feet, includes the Trilobites. The orders may be arranged thus in the ascending order:—

1st order. CLADOCERA. "Small, compressed Branchiopoda ['Phyllopoda' Claus], with non-articulated bodies, mostly with a bivalved shell and free head extended forward, with large oar-like antennæ (ruderarme), and four to six pairs of swimming feet. A single family, *Daphniadæ* (Sida, Daphnia, Polyphemus, etc.)" (Claus.) No metamorphosis, young resembling the adults.

2d order. MEROSTOMATA. Gigantic Branchiopoda, with the head covered by a large or medium sized shield, antennæ forming ambulatory limbs; four to six ambulatory, usually forcipated maxillipedes; abdomen with not over six pairs of lamellate swimming feet, most of which bear gills; and ending either in a caudal spine, or flattened telson. A pair of compound and a pair of simple eyes.

Suborder 1. XIPHOSURA. Body trilobate in the young (Limulus), and often in the adult. Cephalic shield very large, convex, semicircular, bearing (when known) six pairs of forcipated, ambulatory, simple, cephalic appendages, of which the five posterior pairs are provided with coxal spines for chewing the food; a true hypostoma. Metastoma forming two separate tubercles. Abdomen 8–9 jointed, with segments more or less distinct, the terminal one forming a large spine. A slight metamorphosis; the young resembling the adult. Eggs not borne about by the parent during incubation. Three? families. 1. Limulidæ (Euproöps, Prestwichia, Bellinurus, Limulus). Cyclus[3] is perhaps the type of a second family; and the two genera, Exapinurus and Pseudoniscus, possibly, are types of a third family.

[1] "Note on the Palpus and other Appendages of Asaphus from the Trenton limestone, in the British Museum." By Henry Woodward, Proceedings of the Geological Society of London, May 11. Reported in Nature for June 2, 1870.

[2] Claus uses the term Phyllopoda for the order, but Branchiopoda of Lamarck (1801) seems to have the priority, according to Agassiz's Nomenclator Zoologicus.

[3] From the evidence presented by Mr. H. Woodward (Contributions to British Fossil Crustacea, Geol. Mag., Dec., 1870, VII, p. 1) as to the structure and affinities of this most interesting and singular genus of Carboniferous and Permian (l. c., p. 5, footnote) Crustacea, I think we are warranted in regarding it as a member of the Xiphosura. He gives descriptions and figures of nine species, of which *Cyclus Harknessi* Woodward, and *C. Jonesianus* Woodward (fig. 36, *b*, dorsal aspect of carapace; *a*, side view of the same; both magnified four times), are fair examples. The body is hemispherical, and affords no indication of a distinct abdomen; the margin of the body may be compared with the margin of the shield of Limulus. We can also detect the median "cardiac" lobe of Woodward lower down the lateral, and below the marginal lobe, corresponding to the three lobes of

Suborder 2. Eurypterida. Cephalic shield small, flattened, subquadrate. Abdomen elongated, 12–13 jointed, ending in a spatulate telson, or stout spine. Antennæ partially ambulatory and simple, or large and chelate; hind pair of cephalic appendages paddle-like. Metastoma forming a broad plate. Family 1. *Eurypteridæ* (Pterygotus, Slimonia, Styloneurus, Eurypterus), and family ? 2. probably including Bunodes and Hemiaspis.

3d order. Trilobita (*Paleades* Dalman). Body with a thick, dense integument, variously ornamented with tubercles and spines; distinctly trilobate; more specialized than in the Merostomata, being divided into a true head consisting of six segments, covered by a broad, cephalic shield; with 2–26 distinct thoracic segments (probably bearing ambulatory feet), and several (greatest number 28) coalesced abdominal segments, forming a solid pygidium, sometimes ending in a spine, and probably carrying three or more pairs of swimming, respiratory feet.[1] Metamorphosis slight. The young subzoëæform; being

the body of the larva of Limulus and the adult trilobites. In *Cyclus Harknessi* the body is deeply furrowed vertically,

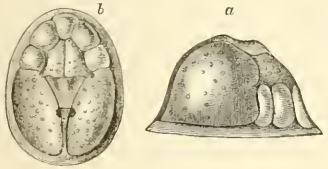


Fig. 36.

while in *C. Jonesianus* the posterior two-thirds of the body is smooth, divided by the cardiac ridge into two elytra-like areas, while anteriorly the surface of the shield is divided into from six (in some species) to eight (in *C. Jonesianus*) lobes. The margin of the body ends behind in some species in a short, small, subacute point. There are no indications of limbs, and very doubtfully of eyes.

Such is a brief description of these problematical remains, in regard to which Mr. Woodward says, in 1868, "We must differ from M. de Koninck in referring this form to the Trilobites. If truly an adult, it must be placed near to Apus, with the other shield-bearing Phyllopods; if a larval form, it may have been the early stage of Prestwichia, or some other Limuloid of the coal-measures. Nor do we think it in the least probable that the shield of *Cyclus radialis* was flexible or contractile, its original segments being completely soldered together into one piece;" and in 1870 he adds that from the recent investigations of Dr. Lockwood and myself, "these forms may indeed be the larval stages of Prestwichia, Belinurus, etc., the antetypes in Carboniferous times of the modern king crab." Were it not for the large size of these fossils, some (*C. Harknessi*) measuring five lines in length, three and one-half lines in breadth, and three lines in height, we should be disposed to agree with Mr. Woodward; but from what is known of the size and form of the freshly hatched larvæ of Limulus and the Trilobites, I should infer that they were either the larvæ of some unknown genus of Limulidæ, or adult, but embryonic, forms. The larvæ of Bellinurus and its allies, Prestwichia and Euproöps, were, in all probability, closely allied in their form and size at the time of hatching to the larva of Limulus. But on comparing the deep, hemispherical form of Cyclus, with the surface of the body deeply lobed over a more or less extent, with the embryo of Limulus before it is hatched (pl. iv, fig. 18, 18 *a*), we find a striking similarity. Indeed we seem to be dealing with a distinct, embryonic type of Limulidæ. In Cyclus we have, in a late larval or possibly adult condition, that state of Limulus in which the body is deeply hemispherical, and the abdomen has just been differentiated from the rest of the body, while the deep, transverse lobes of the yolk are not yet absorbed, as seen in pl. iv, fig. 18, 18 *a*, in the embryo of Limulus; the cardiac or median lobe being as distinctly marked in Cyclus as in the embryo of Limulus.

We may regard Cyclus as a subzoëa, but in its spherical form much nearer the nauplius state than any other Merostomata, having apparently just passed it to enter the early subzoëal stage assumed by Limulus at a comparatively early period in embryonic life. We appear to have, therefore, in Cyclus, whether it should prove to be a larval form, or an adult, a long step backward towards the ancestral nauplius form of the Merostomata. Cyclus, it should be borne in mind, appeared during the Carboniferous period, and affords some slight indication that the Merostomatous type was developed at a considerably later period than the Trilobites, as analogous forms among the Trilobites (Agnostus) appear to me to conform much more to the type of the larvæ of other Trilobites than does Cyclus to the larva of Limulus.

[1] It will be seen by this arrangement that the Trilobites are not regarded as in any way related to the Isopoda, as has been suggested by the earlier writers, Professor Dana, and more recently by Mr. Woodward, the general resemblance being one of analogy. Woodward remarks in the Geological Magazine, July, 1871, p. 291, "In a note upon this specimen (Billings' Asaphus), communicated to the Geological Society, and published at the same time, I ventured to suggest that the evidence put forward by Mr. Billings tended to place the Trilobites near to, if not in, the Isopoda Normalia; and that we might fairly expect to find that the Trilobita represented a more generalized type of structure than the modern Isopods." Passing by certain direct homologies of the adult Trilobites with the Phyllopoda and Merostomata, we might add that the form of the larva is totally unlike that of the young in the Isopoda.

hatched either with none, or one or two thoracic segments. Eggs probably deposited loose in sand or mud. Seventeen families, with very numerous genera and species.

4th order. Phyllopoda. Body with 10–64 distinct segments, naked, or partly surrounded by a flat, shield-shaped or compressed shell, with from ten to sixty pairs of leaf-like swimming feet, provided with well developed gills. Metamorphosis complete; young of the nauplius or zoëa form. Family 1. *Estheriadæ* (Limnadia, Estheria, Limnetis). 2. *Apusidæ* (Apus, Lepidurus). 3. *Nebaliadæ*[1] (Hymenocaris, Peltocaris, Ceratiocaris, Dictyocaris, Dithyrocaris, Argus, Nebalia). 4. *Branchipodidæ* (Branchipus, Branchinecta, Streptocephalus, Chirocephalus, Artemia). It is not improbable that these four so-called families represent suborders.

We have previously indicated the close relationship of the Merostomata, both in their adult and (as far as can be judged from the development of a single genus) larval stages, with the Trilobites. To show still farther the close relation existing between the two groups, I place their characters in opposing columns.

Merostomata.	Trilobita.
Body large and massive, consisting of a head often forming a broad cephalic shield, and abdomen indistinctly or distinctly trilobate.	Body large and massive, consisting of a head, forming a broad cephalic shield; thorax, and abdomen distinctly trilobate.
Frontal doublure well marked.	Frontal doublure well marked.
Compound eyes many facetted; simple eyes.	Compound eyes many facetted; simple eyes wanting.
Hypostoma small, or large, squarish.	Hypostoma large, squarish.
Five to six pairs of cephalic appendages, acting both as jaws and legs.	?
No thoracic segments.	Thoracic segments developed at, and after, the first moult of larva.
Abdomen with segments free or coalesced, forming a broad shield ending in a spatulate or spine-like telson.	Abdomen with segments partially free or coalesced, ending occasionally (Encrinurus, Dalmania) in a spine, or flattened telson (Lichas).
Broad lamellate, respiratory, abdominal feet.	?
Larva, when hatched, like the parent, consisting of head and abdomen only.	Larva when hatched, in some genera differing from parent in wanting thoracic segments.

It appears from the above review that the only fundamental characters separating the two groups, is the addition in the Trilobites, at or after the first moult, of thoracic segments. We should in this connection bear in mind that in the Phyllopoda the number of body segments is constantly varying in different genera, as it is among the Trilobites and Merostomata themselves. The close relationship of the two groups is farther shown by the recent discovery of some remarkable problematical forms by which the Merostomata and Trilobites are apparently linked together. These forms are Hemiaspis (Woodward),[2] Pseudoniscus (Nieszkowski),[3] Exapinurus (Niesz.), and Bunodes (Eichwald).

[1] The late Mr. Salter (Quart. Journ. Geol. Soc., vol. xix, p. 87) has been the first to recognize the close relationship of the fossil genera enumerated above, with the modern Nebalia. It had also occurred to the writer previous to meeting with Mr. Salter's article, that Ceratiocaris was a gigantic Nebaliad. He says, "I have had occasion to study a large series of Silurian Crustacea, which have, in their turn, furnished the data whereby to connect this old Phyllopod (speaking of Peltocaris) with the modern Nebalia and Apus." We are not convinced that there is any real genetic connection between Apus and these fossil Nebaliads, but Mr. Salter's remarks are highly suggestive.

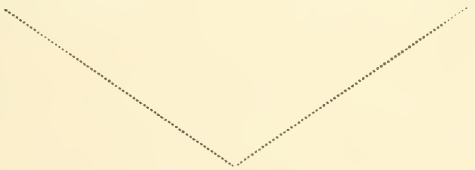
[2] On some Points in the Structure of the Xiphosura, having reference to their relationship with the Eurypteridæ. By H. Woodward. (Quart. Journ. Geol. Soc., Feb., 1867.)

[3] Zusätze zur Monographie der Trilobiten der Ostseeprovinzen, nebst der Beschreibung einiger neuen obersilurischen Crustaceen. Dorpat, 1860.

Of these, Pseudoniscus and Exapinurus seemed nearest allied to Bellinurus, though Mr. Woodward refers them without hesitation to the Eurypterida, while they seem to me to form types of a division intermediate between the Limulidæ and the Eurypteridæ. As to the genera Hemiaspis and Bunodes, they present a remarkable resemblance, whether of analogy or affinity I would hardly venture to say, with the Trilobites, and even possibly indicate a group intermediate between the Eurypteridæ and the Trilobites. In both genera the body is distinctly trilobed, thus (Hemiaspis especially) resembling Bellinurus, (the body of the true Eurypteridæ being smooth). Bunodes, as represented by Nieszkowski, bears a remarkable resemblance to Asaphus and Illænus, in the broad, flat head (though no eyes are present), the five segments between the head and abdomen, and in the form of the latter.

In their most essential characters, *i.e.*, the broad, cephalic shield, the form of the frontal doublure, the large metastoma (of the Eurypteridæ) the compound eyes, and in a less degree the form of the abdomen in some genera, the Merostomata are more closely approximated to the Trilobites than to the Phyllopoda. Add to this the almost identical form of the animals when hatched, and the probability that the mode of development of the embryo of the Trilobites accorded in its main features with that of Limulus, the type of an important group of Merostomata, I feel as if we were almost justified in placing the two groups as subdivisions of an order of the subclass Branchiopoda, and perhaps equivalent to (as much so as natural groups are) the Phyllopoda and Cladocera.

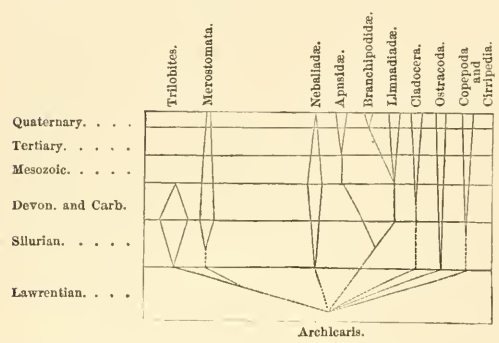
It may seem to naturalists as if it were forcing the Trilobites and Merostomata into an unnatural alliance with the Phyllopoda, but they agree (at least the Merostomata) in having broad, lamellate gill-bearing feet and a more or less developed cephalic shield bearing compound eyes; the Eurypteridæ with their small head parallelizing the Branchipodidæ in their want of a broad cephalic shield. Then the two groups may be represented thus:



Geological Succession and probable Ancestry of the Branchiopoda. The following table may serve to give a rude idea of the relations of the principal groups of the Entomostraca, and their appearance in geological history, so far as the extremely scanty data we possess will allow, while the diagram may also serve as a genealogical tree, showing the probable origin of the main divisions of the lower Crustacea.

As is well known, the Trilobites are met with in comparative abundance in the lowest fossiliferous beds of the Silurian period, and they are the most ancient of Crustaceans, so far as their remains give evidence. The genera Conocephalites, Dicellocephalus, Paradoxides and Agnostus, besides other forms, appear in the Potsdam sandstone or equivalent primordial rocks of this and other countries. The type disappeared during the Carboniferous period, the genera Phillipsia (one species is Permian), Griffithides and Brachymetopus, being the sole representatives of the type which prevailed so extensively during the Silurian.

Simultaneously with the appearance of the larva-like Agnostus, and the more highly organized Paradoxides, etc., we find in the Lingula figures the remains of a species of Nebaliadæ, the *Hymenocaris vermicauda*. Mr. J. W. Salter[1] who was the first author to draw attention to the close relation of the fossil genera Hymenocaris, Ceratiocaris, Peltocaris, Dictyocaris, etc., to Nebalia, has given us a series of sketches showing graphically the geological succession of this group and the Estheriadæ. Hymenocaris, which Salter regards as "the more generalized" type, lived during the primordial period; Peltocaris, and Discinocaris (Woodward) characterize the Lower Silurian period; Ceratiocaris the Upper; Dictyocaris the Upper Silurian and Lowest Devonian; Dithyrocaris and Argus the Carboniferous. No Mesozoic member of the family has yet been discovered, but as there are several species of Nebalia now living in our seas, it is reasonable to suppose that the type has existed in an unbroken succession from primordial times until now. The Palæozoic species were gigantic in size, some being about a foot or more (the carapace of *Dithyrocaris pholadomya* Salter, being seven inches long) in length, while our recent Nebalia is less than an inch in length.



The Potsdam sandstone also contains the remains of a third grand division of Entomostraca, the Ostracoda; remains of Leperditia having been found in Canada, as well as the Lower Silurian of Europe.

No fossil Copepoda have yet been discovered, but we should scarcely wonder at this, owing to their soft bodies. Gerstaecker (Bronn's "Classen und Ordnungen der Thierreichs") suggests that the Lernæans might have infested Paleozoic fish, and on general grounds we should think that they probably extended as far back as the primordial zone, inasmuch as highly developed Trilobites and Ostracodes appear there. Another argument is the interesting discovery made in 1865, by Mr. Woodward, of the Cirripede, *Turrilepas Wrightii*, from the Wenlock Limestone and Dudley Shale of the upper Silurian formation. Previous to this, according to Woodward, "the oldest known Cirripede was the *Pollicipes Rhœticus* from the Rhœtic beds of Somersetshire"; while the type is not uncommon in the Cretaceous, and has flourished from that period to the present.

Of the Merostomata the oldest group is the Eurypterida; the Xiphosura not dating beyond the Lower Carboniferous. The Eurypterids have not been found below the Upper Silurian (Lower Helderberg in America), and the aberrant forms Hemiaspis, Bunodes, Pseudoniscus and Exapinurus are Upper Silurian forms.

Among the Xiphosura, Cyclus, the lowest form, is found in the Carboniferous, and ranges, according to Woodward, as far up as the Permian. In the same period occur Bellinurus, Prestwichia and Euproöps, being in this country found in the lower part of the true coal measures, and found associated in the same beds with Ceratiocaris, Eurypterus (Anthraconectes) and certain Isopoda and Macrurous Decapoda (Anthrapalæmon). The genus

[1] On Peltocaris, a new genus of Silurian Crustacea. Quart. Journ. Geol. Society, London, vol. XIX. 1863, p. 87.

Limulus first appears in the Jurassic, and the species differ but slightly from those now living.

The more typical Phyllopoda made their appearance during the Triassic period. The lowest group, however, the Estheriadæ, appeared during the Devonian, a species referred to Estheria being found in that formation in Europe. The Cladocera are not known to have existed previous to the Tertiary period, and it was not until recently (1862) that Von Hayden discovered the ephippium of a Daphnia in the Rheinish brown coal (Gerstaecker in Bronn's Klassen und Ordnungen, etc.) said by Lyell to be of Eocene age. It should be noticed, however, that the fossil belongs next to Sida, the most highly organized genus of the group, and as it is not unlikely that such pelagic forms as Evadne may have existed in the Mesozoic seas, if not earlier, I have ventured to run the point of the wedge into the Carboniferous period.[1]

The Apusidæ date back to the early part of the Mesozoic, a Triassic species of Apus having been found in Europe, according to Mr. Salter.

The soft bodied and most specialized group of Phyllopoda, the Branchipodidæ, have not been found fossil; and though the conjecture that they are purely Quaternary, or at least Pliocene forms, may be well founded, it would seem as if the question as to their geological age would never be settled, unless impressions of their delicate bodies be preserved in fine grained Tertiary shales.

Our diagram may also be taken as expressing in an exceedingly crude manner the supposed genealogy of the Entomostraca, and the approximate periods when the types of the orders, so far as we know them, were differentiated from the extinct hypothetical prototype or ancestral form. Accepting the theory of evolution as a rational method of accounting for the creation of the species and higher groups of animals, and the fact first brought out by Fritz Müller, that the Crustacea as a rule pass through, either in the egg or larval condition, a nauplius state, and hence that all Crustacea have probably descended from a nauplius-like ancestor, I believe that an attempt, however unsuccessful and apparently fatuitous, to trace, from the few facts we now know, the probable ancestry of the different types of the Crustacea, is logical and legitimate. At any rate the works of Fritz Müller, Anton Dohrn, E. Haeckel and E. Van Beneden, are evidences that mere attempts at a genealogy of the Crustacea have greatly advanced their study, and opened us new fields of research especially in their embryology and anatomy.

Fritz Müller has indicated, and so far as the nature of the case and our present knowledge extends, demonstrated, that the majority of the decapodous Crustacea are born at first as zoëæ; while one of the lowest genera, Penæus, is born as a nauplius, comparable with the young of the Copepoda, Cirripedia, and certain Phyllopoda. Since the young of the lowest Crustacea are born as nauplii, which are comparable with the nauplius of the Decapoda, and since many intermediate typical Crustacea have young of the same form, or pass through a nauplius stage in embryonic life, it seems a reasonable theory of Müller's that the ancestor of all the Crustacea was of the nauplius type.

Müller, however, passed over any consideration of the Trilobites and Merostomata; and were these and the group Nebaliadæ disregarded, there would be no marked exceptions to

[1] Since the above was in type, I find in Giebel and Siewert's Zeitschrift (1870, vol. I, p. 524) a notice of the discovery by Friedrich Goldenberg, of a species of Cladocera, *Lyncites ornatus*, from the Carboniferous rocks of Saarbrucken!

his beautiful theory that the young of all Crustacea are at first nauplii of some form, and that the ancestral form was a nauplius.[1] But on inspection of the diagram, it will be seen that we have highly organized Trilobites and Nebaliadæ existing in the beds of the primordial zone, the lowest platform of life, where the oldest remains of animals higher than the Eozoön are found; while the Merostomata (Eurypterus) suddenly appear in the Middle Silurian, the individuals found indicating as high an organization as the Devonian forms, and we have no hint of any lower forms like them in the rocks below. Thus so far as the facts known at the time of writing may be relied upon, crustacean life exhibiting three very distinct types of structure appeared suddenly upon the surface of the globe. We find no forms peculiarly embryonic (and by embryonic I mean forms resembling the embryos of other animals) among them. Associated with the highly organized Paradoxides, with its numerous thoracic segments, indicating a long series of moults and probably many years of growth after passing through the larval condition, we find the truly larva-like Agnostus, differing only from its own larva by the addition, according to Barrande, of two thoracic segments acquired evidently by one or two subsequent moults. Indeed we have, it would seem, no clue to the hypothetical, primitive, nauplius form. Thus we have in the Trilobites, Merostomata and Nebaliadæ, important exceptions to the mode of development of the individual and of the order in other Crustacea, as we here have Arthropoda which have already acquired a habit of metamorphosis, the embryo maturing into the larva before hatching. We have here, then, an apparent contradiction (1) to the law, in the broadest sense true, that the oldest animals are lower than those now living; (2) to the supposition that the Crustacea may all be traced to a nauplius form, and (3) to the theory that the type has been evolved by secondary laws of creation from an ancestral form, rather than called into existence by a sudden, special, creative act.

In point of fact, however, there are certain exceptions to the first two apparent contradictions, which may be briefly indicated. First, among the Trilobites Agnostus is the lowest form known, and approaches nearest the larvæ of other Trilobites. But neither this genus nor any other larval forms are known to exist above the Lower Silurian. Secondly, among the Branchiopoda (in the extended sense used by us) the lowest forms are often among the largest, though this is a rule which must be used with caution. The Nebaliadæ, as remarked above, were gigantic in size in Paleozoic times compared with the living species, and the species of the primordial zone are unquestionably lower than the living species.

Turning to the Merostomata, we find the Middle and Upper Silurian forms, Eurypterus and Pterygotus, to have attained in some species the almost incredible length of seven feet. These are *mature* forms in distinctions from *larval* forms, the species closely resembling the most highly organized species of the Devonian and Carboniferous age. The latest species (of Lower Carboniferous age) appear to be, so far as known (see Meek and Worthen's Anthraconectes, nearly a foot in length probably), of much more moderate size. The earliest Xiphosura, Bellinurus and allies (and possibly Cyclus), were much smaller than their more highly developed modern representative, the king crab, which sometimes

[1] "I have not mentioned the Pycnogonidæ, because I do not regard them as Crustacea; nor the Xiphosura and Trilobites, because, having never investigated them myself, I knew too little about them, and especially because I am unacquainted with the details of the explanations given by Barrande of the development of the latter. According to Mr. Spence Bate, 'the young of Trilobites are of the nauplius-form,'" p. 96. It should be borne in mind that "Für Darwin" was written by the author while living at Desterro Island, on the coast of Brazil.

attains to a length of nearly three feet; the Carboniferous types were small and essentially larval, while Cyclus was on the whole embryonic in appearance. Thus the lowest members of one group may be the largest, and in a closely allied group, the lowest types be the smallest. In the Decapoda, the largest crabs are found in the highest families, while the lowest Anomoura are the smallest, the lobster many times exceeding Alpheus and Penæus. The lowest Copepoda are the smallest, the Argulus being gigantic compared with the lower forms. So Evadne, etc., the lowest Cladocera, are the smallest, Sida and Daphnia greatly exceeding the former in size.

In reply to the second objection, *i. e.*, that the young of the three oldest groups of Branchiopoda (Trilobites, Nebaliadæ and Merostomata) present no relation to a nauplius-like form, I have endeavored to show that the Limulus passes through a nauplius condition soon after the primitive disc appears. The growth of the embryo is at this period remarkably accelerated, and the transitory nauplius state is rapidly effaced, somewhat as Dohrn has shown to be the case in the Decapoda. The third objection falls to the ground if my opinion that the germ at first represents the nauplius condition should be proved. Limulus and the Merostomata as a group, do not, then, offer so remarkable an exception to the other Crustacea as would at first appear, and it should be remembered that the Trilobites in all probability were developed in the same manner as Limulus.

The dotted lines in the diagram indicate the probable line of development of the Entomostracous Crustacea. We have to assume from the facts stated above, the existence of an Archicaris,[1] a hypothetical animal, resembling a larval Copepod, with a rounded, ovate body, not differentiated into head, thorax and abdomen, and with one or two pairs of swimming appendages representing the most anterior cephalic limbs of the Copepoda. This animal we assume to have existed at some time previous to the Silurian age, perhaps towards the close of the Lawrentian period. At certain intervals between the appearance of this Archicaris and the larval Silurian Agnostus, must have appeared a few intermediate forms of family, or perhaps subordinal, rank, whose offspring partook of the Agnostus form. The transition from a somewhat spherical germ to a flattened Agnostus, may, on the other hand, have occurred, say, in a few thousand generations; the transition from a spherical germ to a flattened larval form, with a distinct head and abdomen, in geological time, being exactly paralleled by the mode of evolution of the individual Limulus from a spherical, nauplius-like germ, as seen in Pl. III, fig. 13, to a more or less flattened, hemispherical subzoëan embryo, such as is represented in fig. 19, of Pl. IV. We shall have to assume, then, the existence of a second main ancestral form uniting the Trilobites and also the Xiphosura (and probably the whole order Merostomata) with the Archicaris. Now Cyclus is the most embryonic of the Merostomata we are acquainted with. The link may have been related in form to this genus, and hence I would propose the term *Protocyclus* for this hypothetical animal, which must if at all have flourished in the Lawrentian period. In the diagram this Protocyclus may be located at the junction of the dotted lines leading from the Trilobites and Merostomata to the Archicaris. These Lawrentian forms were in all probability not free swimming types like the nauplian young of the Crustacea now living, but very likely crawled over the bottom, in the mud, respiring through their skin like the modern nauplius. They probably adhered to a burrowing life, like the

[1] See Haeckel's Natürliche Schöpfungsgeschichte, 1870, p. 488.

king crabs of to-day, and thus dispensed with the use of functional antennæ; these organs morphologically such, retaining the locomotive functions as in existing nauplii. A step higher and we have the Protocyclus, with short, ambulatory, cephalic limbs, the front part of the body adapted still better than before for burrowing in the fine sand and mud, no antennæ being developed, while under the abdomen, the integument of the body having meanwhile become harder, may have grown rudimentary, gill-bearing phyllopodous feet, like those of the embryonic Limulus. With the gradually flattening form of the body, and small, swimming feet, the Protocyclus may have adopted, at times, a more roving life, and thus the type became widely distributed. In some such mode as this we should expect that a burrowing Archicaris gradually assumed the Cyclus and Agnostus forms. On the other hand, the ancestral Eurypterus must have swam more freely than the Protocyclus, since the appendages in this type representing the antennæ are not only ambulatory organs, but also well adapted for seizing and biting; while the body lengthens out and the respiratory feet are moved forwards from the telson, in unison with the requirements of more or less rapidly moving predatory Crustaceans, as these forms undoubtedly must have been.

The Nebaliadæ are the most aberrant group of true Phyllopoda we have to deal with. Metznikow, who has studied their embryology, concludes, as Müller states, that Nebalia, during its embryonal life, passes through the nauplius and zoëa stages, which in the Decapoda occur partly (in Penæus) in the free state. "Therefore I regard Nebalia as a phyllopodiform Decapod." While I would not regard Nebalia with its eight pairs of well developed thoracic phylliform feet, with the peculiar phyllopodous carapace adhering to the head alone, as a Decapod, yet as remarked long ago by Milne Edwards, "Elles semblent, à plusieurs égards, établir le passage entre les Mysis et les Apus." The zoëal forms that we see in the Phyllopoda and Eurypterida culminate in the embryonic zoëa of Nebalia.

On glancing at the diagram it will be seen that the Nebaliadæ hold the centre, and present an almost unbroken succession of forms from the lowest Silurian to the present day. The true zoëal forms began with them. Their Lawrentian, nauplian ancestors must have been free swimming forms, and in accordance with this habit, have by a continued roving and more or less predatory life retained their sense organs or antennæ comparatively unaltered, while after a series of nauplian moults, resulting in a fixed habit of metamorphosis, swimming respiratory feet were developed near the head, while the rudder-like abdomen terminated in a bifid or trifid telson, and two pairs of small abdominal feet were gradually developed. Thus we have comparatively highly organized metabolous Arthropoda at the dawn of the Silurian age; and if there is any truth in a development hypothesis, we have the strongest reasons for supposing that they were preceded by simpler ametabolous forms in an age anterior to the deposition of the lowest Silurian fossiliferous rocks, perhaps the Huronian and even the upper Lawrentian period.[1]

At any rate the earliest known Crustacea appear in highly developed forms representing four (if we include the Merostomata) important groups of Entomostraca, and one, the most

[1] While in the Insecta, as Fritz Müller has indicated, the ametabolous insects were the older, and the "complete metamorphosis" of the Coleoptera, Diptera, etc., a subsequently acquired one; so also in the Crustacea those Branchiopoda with the most complete metamorphosis, such as Estheriadæ, Branchiopodidæ, and Apusidæ, are the most recent forms, while those with an incomplete metamorphosis (Trilobites, Merostomata, and Nebaliadæ) are the earliest Branchiopoda. And we have every reason to believe that the Copepoda and Ostracoda, etc., the former with a slight, and the latter with scarcely any metamorphosis at all, were the earliest of all the Crustacea; the primeval nauplius being a low Copepod.

comprehensive or synthetic type of all, the Nebaliadæ, presenting certain features found only in the Decapoda. It seems impossible to my mind that at the dawn of Silurian life these well marked groups were due entirely to the extinction of multitudes of connecting links, such as Mr. Darwin assumes to have been evolved on the principle of natural selection, with the subordinate agency of sexual selection and mimicry, etc. The groups are almost as clearly marked as in the present time, and such a theory seems to me inadequate to account for the rise of such distinct forms, apparently simultaneous in their appearance at the beginning of the Silurian. The forms are remarkably isolated and present every appearance of having been in a degree suddenly produced; by this I mean that the Archicaris may have evolved the Protocyclus after thousands rather than millions of generations, and that the young differed from the parents in a more or less marked degree, the changes being perhaps superinduced in the embryo by change of habits and temperature, and depth of water experienced by the adult. I am strongly inclined to believe that the great differences in the egg, the development of the primitive disk, the singular amnion and the almost ametabolous young of Limulus, so unlike other Crustacea, are possibly due to the eggs being laid by the parents in the sand or mud between tides; this being an exception to all other Crustacea so far as I am aware, unless we except Squilla and Gecarcinus, which also lay their eggs in the sea, but in what manner we are not fully informed. To withstand the action of the waves, the alternations of heat and cold, the chances of being even left for weeks and perhaps months on dry land, before an extra high tide can bear them back into the water, the yolk cells must be small and exceedingly numerous, so as to make the egg contents unusually compact, as they are in Limulus. So also must the chorion be dense and thick and remarkably unyielding, as we find to be actually the case in the King Crab. Then again, when the embryo increases in size, instead of the young hatching as in other Crustacea, it is in the present instance retained within the egg by a vicarious chorion, *i. e.* the remarkable amnion, with its toughness and enormous cells, so unique in the Arthropoda.

Finally, we find that all these characteristics, so unmistakeably correlated with the precarious life of the egg, seem to tend to prolong the life of the embryo within the egg, until the young Limulus is hatched in the form of the adult, the metamorphosis being of the slightest possible character. It is evident that the retention of the embryo within the egg, has taken place in order that the embryo may pass through the nauplian and subzoëal conditions to attain the larval form so like the adult; or in other words the metamorphoses are undergone within the egg instead of after leaving it. That the differences in the egg of Limulus from those of most other Crustacea are due to physical causes, and induced by them rather than correlated with them, is shown in the summer and winter eggs of the Cladocera, the long period of winter causing the eggs which are laid in the autumn to have an extra protection. The eggs of the Estheriadæ and of Apus and the Branchipodidæ which fall into the bottom of pools which dry up, are also covered by a dense chorion to protect the germ from sudden alternations of heat and cold and wet and dryness; and in Apus, though the development of the young is accelerated, and the metamorphoses are extra-ovular, we have the amnion acting as a vicarious chorion. On the other hand, the eggs of Nebalia, retained beneath the body until the young are hatched, are soft, with large yolk cells, and a thin, transparent chorion. Here again, in conditions always remaining the same, the young is born a zoëa, closely resembling the parent, the metamorphoses being intra-ovular. These divergences in the habits and mode either of oviposition or non-

oviposition of the ova, I conceive to have been comparatively suddenly induced. It should be remembered that at the present day we find great differences between the eggs and mode of formation of the blastoderm in the eggs of the fresh water Gammarus and their congeners previously alluded to. I conceive these differences to be due perhaps to sudden changes of temperature in fresh water pools, to the difference in the density of fresh and salt water, and the liability of fresh water pools to dry up, combined with less apparent causes. We have indicated that Limulus develops from a primitive disc, like that of the fresh water *Astacus fluviatilis*, whose mode of development is so unlike that of the marine allied forms. In a more remarkable degree are sudden divergences shown in the species of Eriphia, Crangon and Palæmon, whose development has been studied by Rathke (see p. 162). In these cases the primitive band is more circumscribed, the germ starts differently and the metamorphosis is passed within the egg, instead of after hatching; while, as is well known, the other species of these genera are developed in the normal mode, the young being hatched and passing through a series of complicated metamorphoses. Again, in the Gecarcinus we have one species which, according to Professor Westwood, undergoes no metamorphosis, the embryo being developed, as his figures indicate, as in Astacus and the other species above noticed. A remarkable exception to the ordinary laws of oviposition occurs in the salamanders. While most of our salamanders lay their eggs in the water, and the young live in the same element. Mr. F. W. Putnam[1] has found the eggs and young of *Plethodon erythronotum* under the moss and bark of decayed trees in the woods late in August. A number of young had just hatched, as they retained their gills, which dropped off about three days after hatching. Professor Baird (Tailed Batrachia of North America) had also previously stated that the eggs of this species are "deposited in packets under damp stones."

Divergences from the normal mode of development of the group occurring at the present day, are strong indications that the differences in the structure of the three groups of Crustaceans of the primordial zone were induced with comparative suddenness. Thus the accelerated and metabolous growth of the Nebaliadæ point to a deeply seated law of growth perhaps best expressed by the terms "acceleration and retardation of development," first proposed by Prof. Cope. And just as in the growth of the individual, the adult form is attained by cell growth and the acceleration of growth in one part, and retardation in adjoining regions, and sexual forms are determined by the unequal development of the primitive cells of the generative organs in two different individuals, and just as the individual undergoes both during and after embryonic life, a series of changes we call metamorphoses, which are simply "expression points" in the life of the individual,—so we find a parallel series of similar causes and effects in the evolution of the species, genera, orders, and higher groups of organized beings. Prof. Hyatt has shown (1866) that the development of the order is paralleled by that of the individual in the Cephalopoda. It is therefore to the laws of ordinary growth, of the production of the sexes, of metamorphosis and of parthenogenesis, that we must go for an explanation of the laws of evolution. It should be borne in mind that though we see individuals produced before our eyes and behold sexual differences and reproduction by parthenogenesis, we do not yet know the causes that produce these effects. And so because we do not actually behold species and genera created by natural laws, it does not

[1] Proceedings Boston Soc. Nat. Hist., 1862, IX, p. 173.

follow that there are not causes in operation that result in the evolution of specific and higher categories among organized beings.

The appearance however, of the three highly developed types of Crustacea, in the primordial period, indicates quite plainly that these and probably all the orders and perhaps suborders of this class had an independent origin, and have not diverged one from another at different periods. If the Nebaliadæ are a simple family of Phyllopoda, then we have the case of a family form starting in the lowest zone of the Silurian and surviving until the present day in undiminished vigor, and indeed in a rather more highly organized form than at the start. If the Decapoda were not derived from some Silurian ancestor which drew its origin independently from some Lawrentian nauplius, I do not see from our present facts how they could have branched off from the Silurian Nebaliadæ, as we have no intermediate types; but speculation is useless where further discoveries may any day reveal connecting links. But according to our present knowledge the Decapoda and Tetradecapoda probably arose independently of the Branchiopoda, and the types became fixed late in the Silurian. For these reasons I am unable to agree with the opinion of Dr. A. Dohrn[1] that the "Decapoda, Stomatopoda, Edriopthalma, as well as the Cladocera, Ostracoda, Copepoda and Cirripedia have arisen from the Phyllopoda." This is denying a common nauplius ancestral form for the Crustacea. Moreover, Dr. Dohrn seems to have overlooked the fact that well developed Ostracoda (Leperditia and Primitia, represented by eight species), so far as the valves of the carapace indicate, flourished in the lowest Silurian zone both in Europe and America, and the probabilities are that they had companions of their own order at least. For this reason, if no other, we would also question whether as Dohrn claims, the Ostracoda are degraded, retrograde Phyllopoda.

Since this article has been in the hands of the printer I have received (Jan. 16, 1872) from Dr. A. Dohrn his essay "Zur Embryologie und Morphologie des Limulus Polyphemus" (Jenaischen Zeitschrift, Band VI, Heft. 4); with the few exceptions noticed below I am greatly pleased to find both Dr. Lockwood's and my own conclusions in the main confirmed by this able investigator. Dr. Dohrn concludes that "Limulus is nearest related to the Gigantostraca; both appear to be related to the Trilobites, though this relationship cannot be established in all the details. The morphological and genealogical relations of these three families to the Crustacea are not such as to be surely determined, perhaps they will remain always doubtful. That they are related to the Arachnida we are not as the matter now stands in a position to allow. So it only remains for us to put these three groups under a common name, for which I might adopt Haeckel's expression 'Gigantostraca' and let them take their place in the system with (*neben*) the Crustacea." Whether I have gone too far in enlarging the old group Branchiopoda to include the Merostomata and Trilobita, I leave to zoologists to decide. I think that since embryology throws an uncertain light upon the subject, the question will have to be decided by a study of the young and adult stages; and from the fact that Limulus and the Eurypterida have branchial feet, comparable with those of the Phyllopoda (the fact that the lamellæ on the second pair in Limulus are arranged like the leaves of a book, while in Pterygotus they are arranged side by side like the teeth of a rake, to which Dr. Dohrn compares them, shows that the number and char-

[1] Geschichte des Krebsstammes, nach embryologischen, etc. Jenaische Zeitschrift, Bd. VI, Heft. I, 1870.

acter of these gill-like divisions of the feet vary so as to be only a family or generic character), while the frontal doublure and hypostoma of the Trilobites are directly homologous with those of Apus, I judge that the two groups belong here if anywhere among the Crustacea. As to the points of disagreement, Dr. Dohrn remarks on p. 609, "Only one error which might possibly cause confusion, must I here notice. Dr. Packard considers what I have above described as the exochorion, to be the true chorion; and what I regard as the chorion, he calls at one time inner egg-membrane, then amnion, and finally the homologue of the 'larval skin' of German embryologists."

I may say that at first I was, with Dr. Dohrn, disposed to regard the structureless chorion as an exochorion, but after careful and repeated observations on the ovarian eggs, and those that had begun to develop, I found that the egg was surrounded at the time of oviposition by but a single membrane, viz., the chorion; and that it was formed in the ovary in the normal manner by being evidently secreted by the epithelial cells of the ovarian tubes, as I could see them partially surrounding the partly formed eggs. After the examination of hundreds of eggs freshly laid I failed to find any other membrane until just at the time of the formation of the primitive disc. The observations and drawings I have presented in this article, prove, I think, that Dr. Dohrn's "chorion" is the first blastodermic moult; as I have observed, unless greatly mistaken, the membrane splitting off from the primitive band. How successful I have been in homologizing this blastodermic moult with the "amnion insectorum," *i. e.*, of the hexapoda and the scorpions, I leave to the judgment of embryologists. I might add that Gegenbaur (l. c., p. 249) notices the transformation of the cuticula into the egg membrane, but does not describe any other membrane in the egg.

Secondly, Dr. Dohrn errs in saying that I have homologized this amnion with the "larval skin." Indeed I have not mentioned them even on the same page (see American Naturalist, IV, October, 1870, pp. 500, 501, and Proceedings of the American Association for the Advancement of Science, published in August, 1871). What I then wrongly called a nauplius skin, doubtfully referring it to the "larval skin" of German embryologists, I call in this final article subzoëal skin, and the homologue of Van Beneden's "cyclopian skin."

On p. 582, Dr. Dohrn states that in the earliest stage he could observe, there were visible the rudiments of only five pairs of appendages. I might say that I have examined hundreds (I believe over a thousand) living eggs, as well as those that had been hardened in spirits, in order to ascertain whether the germ first appears with less than six pairs of legs, but without success.

Dr. Dohrn does not regard the earliest condition of the embryo of Limulus as a nauplius. I may say that in regarding the earliest stage of Limulus as a nauplius, which I have done with some reservation, I was led to do so partly on theoretical grounds, on the principles advanced by Dr. Dohrn himself in his able works on the embryology of Crustacea. If the earliest stage of Daphnia (see his Untersuchungen über Bau und Entwicklung der Anthropoden, p. 56, pl. I, fig. 8), or Scyllarus and Palinurus (Zur Entwicklungs-geschichte der Panzerkrebse, pl. XVI, figs. 3, 4) represented truly the nauplius stage, then it occurred to me that the corresponding embryonic stage of Limulus represented a nauplius condition. The greater number of limbs in the germ of Limulus seemed to me of slight consequence. In either case the comparison with the nauplius of the Copepoda, or even of Penæus, is in a degree hypothetical; and many zoologists will probably regard the likeness as of little significance unless strongly biassed by evolutional views; just as the comparison of the

earlier stages of embryonic mammalia with the fishes and reptiles is to some minds very significant, while to others differently constituted it is of little importance.

To give completeness to this article I might cite Professor Huxley's latest expression of his views as to the affinities of the Xiphosura. Dohrn quotes him as saying in the "Academy" (Nov. 13, 1869, p. 42) "I imagine that the Copepoda represent the hypothetical Archæocarida most closely. Apus and Sapphirina indicate the relations of these Archæocarida with the Trilobita, and the Eurypterida connect the Trilobita and the Copepoda with the Xiphosura. But the Xiphosura have such close morphological relations with the Arachnida, and especially with the oldest known Arachnidan, Scorpio, that I cannot doubt the existence of a genetic connection between the two groups."

Finally Prof. E. Van Beneden (on the Systematic Position of the King Crabs and Trilobites, Annals and Mag. Nat. Hist., Jan., 1872, copied from Comptes Rendus de la Soc. Entom. Belg., Oct. 14, 1871) after referring to Strauss-Durckheim's opinion that the Gnathopoda (Limulus) should form a separate order of the class Arachnida, remarks as follows: "The Limuli are not Crustacea; they have nothing in common with the Phyllopoda; and their embryonic development presents the greatest analogy with that of the Scorpions and other Arachnida, from which they cannot be separated. . . . . The Trilobites, as well as the Eurypterida and the Pœcilopoda, must be separated from the class Crustacea, and form, with the Scorpionida and the other Arachnida, a distinct branch, the origin of which has still to be ascertained."

Still later than Prof. Van Beneden's paper appears (as reported in "Nature" for Jan. 17, 25, 1872) a paper "On the Anatomy of Limulus Polyphemus" by Prof. R. Owen, in which he adopts the view held by Prof. Dana, that the telson of Limulus represents the abdomen; hence "the very fact of the late appearance of this terminal division was decisive against any real representative resemblance of the embryo Limulus to the Trilobites." He also believes that there is "neither a nauplius stage nor a trilobite stage" in the embryo of Limulus; though he considers Limulus a Crustacean.

Fig. 36.

On a deformed caudal spine of Limulus. The accompanying figure represents, reduced one-half, a spine of a specimen of L. Polyphemus which I found in company with Dr. E. Coues, at Fort Macon, North Carolina. The specimen was twice the size represented by the cut, and was bifurcate at the extremity in the manner shown by the figure. I am inclined to believe that this deformity is very rare.

Explanation of Plates III–V.

Fig. 1. Spermatozoa of Limulus Polyphemus, magnified about 400 diameters.

Fig. 2. Cell-egg of Limulus attached to the ovarian tube; *n*, nucleolus, or Purkinjean vesicle; *pl*, layer of protoplasm surrounding the nucleus. 2*a*, epithelial cells lining the ovarian tube, × 210 diameters. 2*b*, a fold or ruffle of the tube consisting of epithelial cells destined to become eggs, × 210 diameters. 2*b*, 2*c*, earliest form of the cell-egg, with the nucleus. 2*d*, the same a little larger; all × 130 diams.

Fig. 3. A cell-egg attached to the ovary, × 130 diams.

Fig. 4. An older cell-egg, with yolk cells developing, × 130. (The nucleus should appear lighter than the rest of the egg).

Fig. 5. A still older egg with one or two yolk cells nearly as large as the nucleus, *n*, × 130 diams.

Fig. 6. A portion of the surface of the freshly impregnated egg, showing the blastodermic cells, × 30 diams. 6*a*, the same, × 130 diams. 6*b*, An egg after the primitive cells have disappeared, × 30 diams.

Fig. 7. The same as 6*b*, a little farther advanced, × — diams.

Fig. 8. Profile, and 8*a* vertical view of the blastodermic cells before the amnion is moulted, × 130 diams.

Fig. 9. Amnion (*p*) not yet moulted; *ch*, chorion; *y*, yolk cells; × 130 diams.

Fig. 10. The primitive disc (*pm*), the curves indicating the protozoonites; *y*, yolk; *ch*, chorion; × 50 diams.

Fig. 11. Cells of the amnion after the chorion has split apart, × 400 diams. 11*a*, profile view of the same less magnified.

Fig. 12. Upper figure partial profile, lower figure front view of the embryo as it first appears; *m*, mouth. 12*a*, the embryo farther advanced than in fig. 10, and showing at *a* the amnion beginning to split off; seen more distinctly at 12*b*, the rest being seen at *a*.

Fig. 13. The embryo farther advanced, with the finger-shaped rudimentary limbs. The dotted portion represents the amnion.

Fig. 14, 14*a* and 15. The same in a little earlier stage than Fig. 13; *pm*, amnion; *x*, yolk masses detached before the formation of the blastodermic skin. These and 13 represent the nauplius stage.

Fig. 16. The beginning of the subzoëan stage, signalized by the appearance of the two pairs of abdominal appendages (*ab*), and the appearance of the protozoonites on the back of the embryo.

Fig. 17, front, 17*a*, profile view of the embryo farther advanced, with the indications of a third pair of abdominal appendages.

Fig. 18, 18*a*. The same still farther advanced, showing at *z* the skin peeling off, being the first subzoëal moult.

Fig. 19, 19*a*. The abdomen is now differentiated from the head, with the segments well marked; the five lobes of the liver indicating the five posterior cephalic segments.

Fig. 20. Posterior view of an older individual, showing the abdominal segments, and the three pairs of gills and the dorsal vessel.

Fig. 21. Another view, with the abdominal segments left out, but showing the flagrum (*f*) and the lower edge of the carapace.

Fig. 22. Rudimentary gills, divided each into two lobes; the gills are shown in a later stage in fig. 24*b*.

Fig. 23. The middle and posterior feet; *d*, sixth pair.

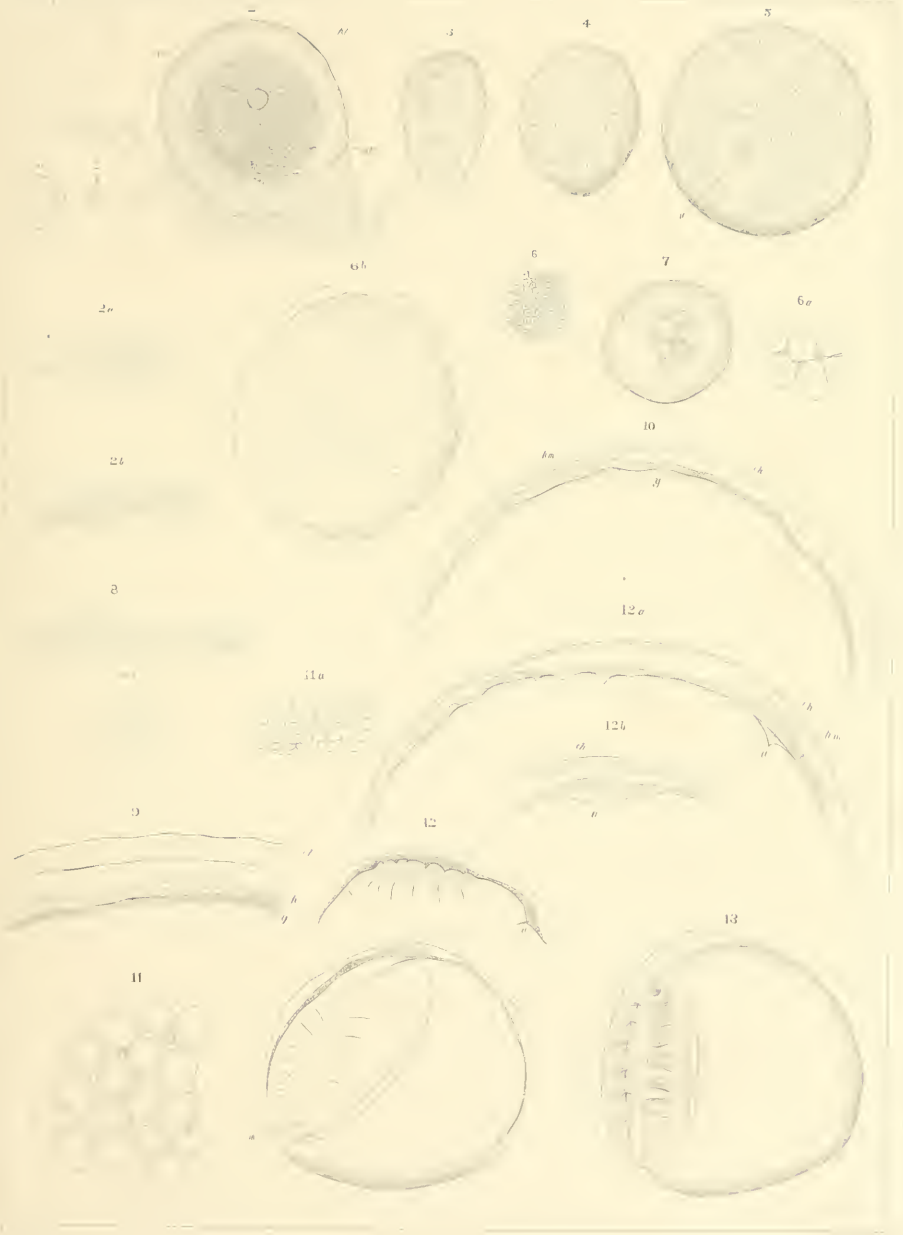
Fig. 24, 24*a*, 24*b*. Different views of the embryo just before hatching, showing the trilobitic stage of the young. 24*c*, a middle leg.

Fig. 25, 25*a*, 25*b*, 25*c*. Different views of the freshly hatched young; *c*, cardiac lobe, *o*, opthalmic ridge.

Fig. 26. Second pair of abdominal appendages of the larva, bearing the gills. 26*a*, outer or first pair of abdominal appendages; 26*b*, the same, at an earlier stage.

Fig. 27. Larva after the first moult, having acquired the rudimentary spine, also showing the circulation as seen in the living larva; the feathered arrows indicate the arteries, and the arrows with a simple shaft the course of the venous currents; *i*, intestine. The lobules of the liver are seen in the head and sending two lobes into the abdomen alongside of the intestine.

Note. Figs. 16, 19, 19*a*, 24, 24*a*, 24*b*, 24*c*, 25, 25*a*, 25*b*, 25*c*, 25*d*, were drawn by Mr. J. H. Emerton. The observations were made with a Tolles' triplet and Zentmayer's Hospital microscope, with his inch and a half and 4-10 objectives.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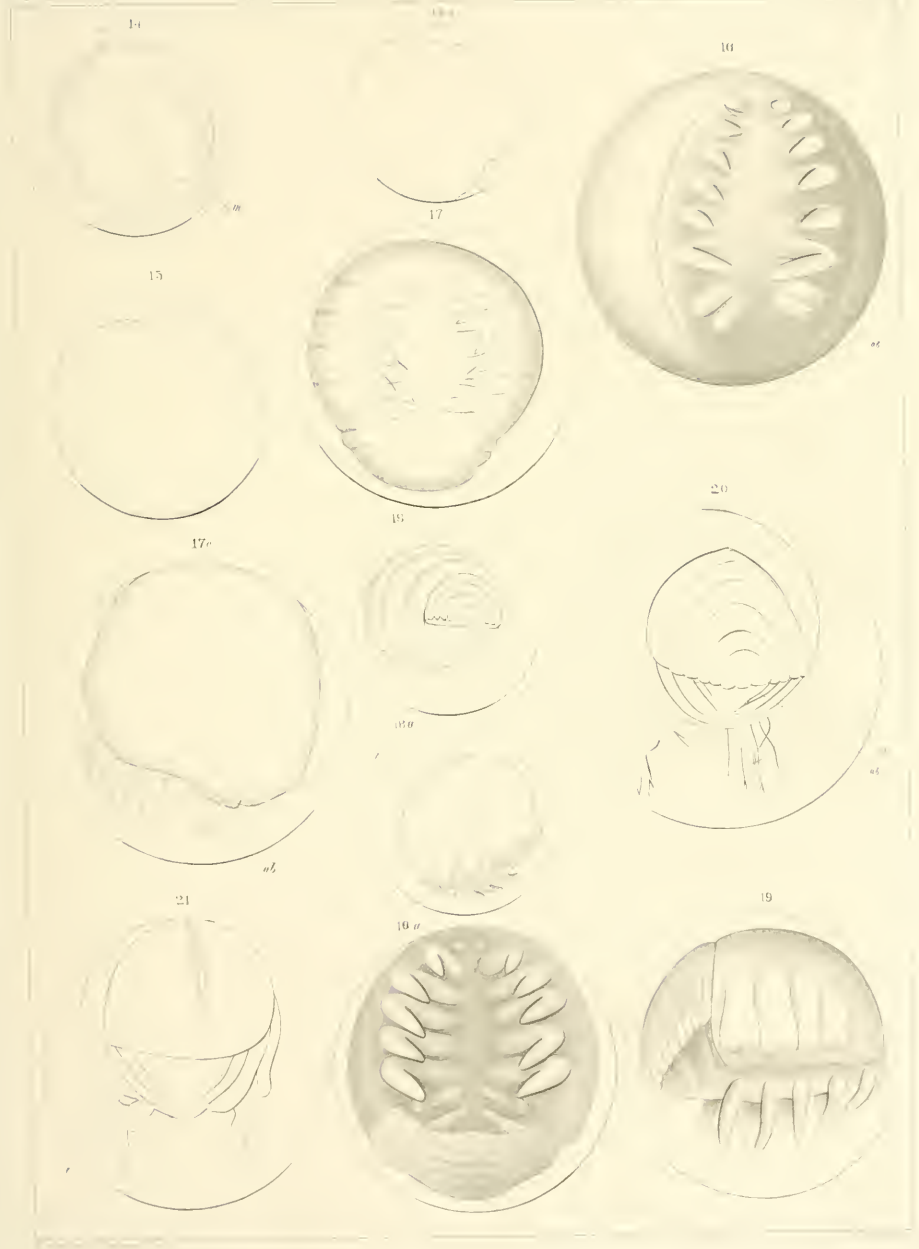
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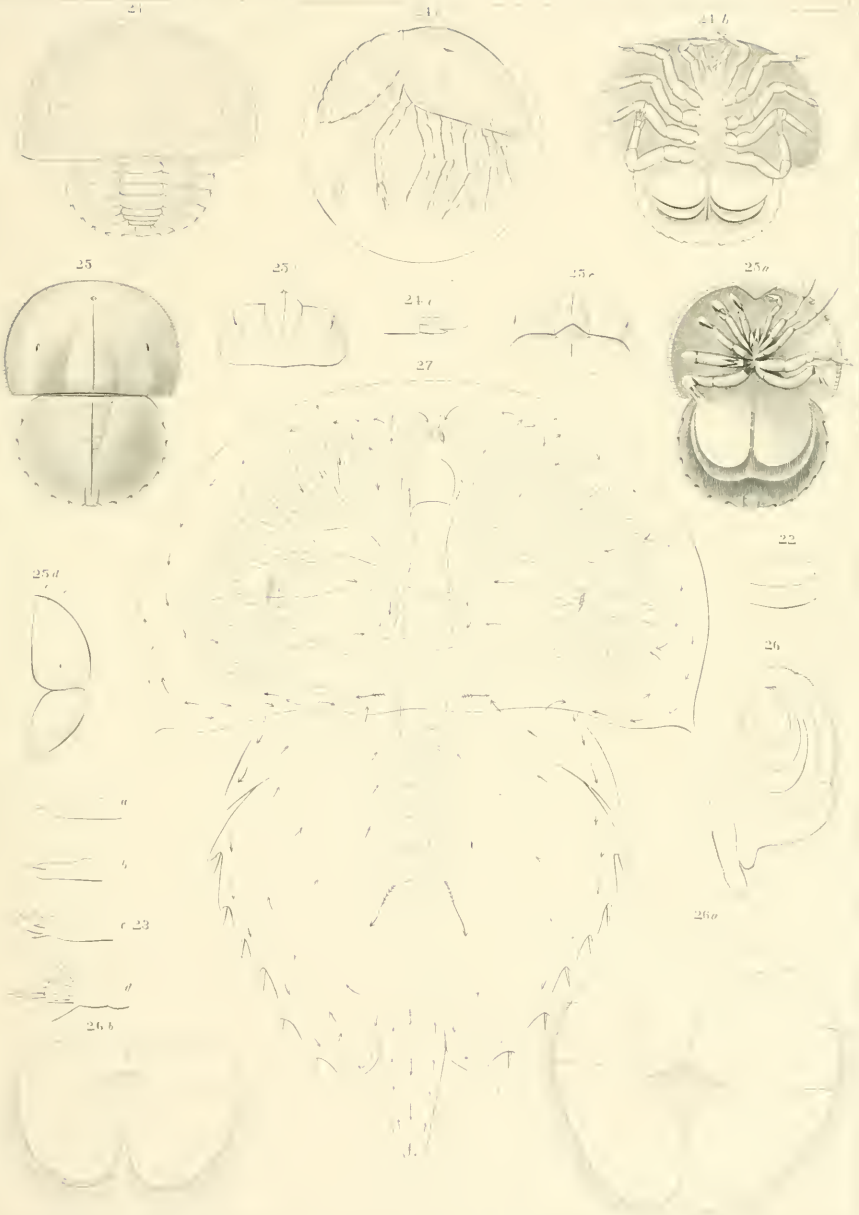
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V. Description of the Whale (*Balænoptera musculus* Auct.) in the possession of the Society: *with remarks on the classification of Fin Whales.* By Thomas Dwight, Jr., M.D.

Read May 17, 1871.

As a minute description of the skeleton of the most common species of Fin Whale may at first sight appear superfluous, it is desirable to state at once the purpose of this paper.

The classification of the Finners is in the greatest confusion, which is increased by the tendency of many zoologists to form new genera and species, ignoring the fact that the number of well described specimens is not sufficient to warrant much generalization. The task undertaken is to add one to the list of thoroughly described skeletons, and to endeavor to show that the range of purely individual variations is greater than is generally admitted.

The whale was a female, 48 feet long. The skeleton, just short of 45 feet (the curve being represented and the intervertebral cartilages suppressed), is now hanging in the large hall of the Society's Museum. Having no account which I know to be authentic of the capture of the animal, I copy a part of the commonly accepted one, from the *Boston Daily Advertiser* of Monday, October 17, 1870.

"A whale about sixty feet long was captured off Gloucester, on Saturday, and was towed up to this city yesterday, where it can be seen at Litchfield's wharf. We understand that the whale was first seen floating on the surface of the water by some fishermen, who supposed that it was dead. They went to it and succeeded in fastening a hawser to its jaws, when it began to 'come to' and soon gave unmistakable signs of life, thrashing round so that the boats were upset and the hawser parted. They, however, continued their attacks upon him, and after the third attempt they succeeded in putting a period to his existence, and a tow line round his jaw, which held. . . . . As far as had been ascertained, he had received no injuries before being seen by the fishermen, and it is supposed that its torpid condition was owing to sickness."

It was exhibited, according to this announcement, for about ten days, when the proprietor, Mr. H. T. Litchfield, having removed the blubber, presented the carcase to the Boston Society of Natural History. The flukes of the tail were cut off shortly after the capture, and the whalebone fell a sacrifice to the popular enthusiasm. While the whale was on exhibition and its destination still in doubt, Mr. J. A. Allen, of the Museum of Comparative Zoölogy, examined it and took many very accurate measurements. Mr. J. H. Blake, of the same institution, made the drawings which appear in plate VII, and woodcuts 1 and 2. All these were very handsomely given me by Mr. Allen, when the whale came into the possession of this Society. The carcase, by this time exceedingly offensive, was towed to an island in the harbor and dissected under the superintendence of Professor Hyatt, Mr. Sanborn and myself. As I was unable to be absent for a long time from the city, by far

the greater part of the work was done by these gentlemen, to whose ceaseless vigilance we owe the perfection of the skeleton. Decomposition being far advanced, the accommodations on the island barely comfortable for the season, and communication with the main

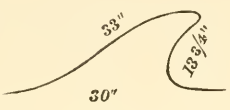


Fig. 1 — Dorsal Fin.

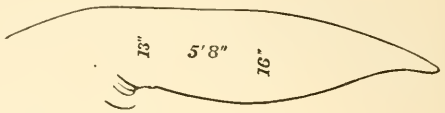


Fig. 2. — Flipper.

land irregular, all ideas of making a study of the muscles and viscera were abandoned, and all the care concentrated on the bones. (In this paper, to avoid too much repetition, I shall occasionally allude to this as the *Boston Whale*, it being the only large whale in the city proper, and the only specimen of this species that is likely to be here).

External Appearance. The following measurements and description are Mr. Allen's.

	ft.	*in.*
" Total length	48	
Circumference of the head at the eye	23	8
Distance from the eye to the end of the upper jaw	9	8
" " angle of the mouth to the end of lower jaw	11	1
" " eye to the blow-holes	3	6
" " " " auricular opening	2	3
" " " " base of the fore limb	4	11
" " end of the upper jaw to base of fore limb	14	7
" " dorsal fin to the fork of the tail	11	5
" " anus to the fork of the tail	14	3
" between anus and vulva	1	3
" " " umbilicus	6	8
" from the umbilicus to the fork of the tail	20	11
Length of the fore limb	5	4
Greatest width of the same	1	4
Length of the dorsal fin (measured along the anterior edge)	1	2
Breadth of the dorsal fin at base	2	7
" " tail two feet in front of the flukes	3	0
" " flukes at the base	2	7
" " tail just in front of the flukes	2	6
Distance from the median line of the back to the insertion of the fore limb	5	4
Distance between each flipper and the blow-holes	4	8
Length of the mammarial fissure	1	1
Length of the eye (entire length)	0	4.5
Breadth of the eye	0	1.83
Length of the eye ball	0	2
Breadth of the eye ball	0	1.75
Length of the blow-holes	0	6
Greatest diameter of each fissure	0	1.5
Distance apart posteriorly	0	6.5
Distance apart anteriorly	0	5

"The body is greatly compressed towards the tail, its vertical diameter two feet in front of the flukes being fully twice the transverse diameter at the same point. The greatest number of plicæ on each side of the median line was about twenty-eight. The color above was nearly uniform, slaty black, rather gradually shading off to white on the sides, with anteriorly several oblique, irregular, alternating bands of whitish and dusky. Below, entirely white, except the furrows formed by the plicæ, which were of the color of the dorsal surface. After the animal became distended with gases so as to open the furrows between the plicæ, the ventral surface presented the appearance of alternating narrow, longitudinal black and white stripes."

The whalebone, as already intimated, was quite destroyed by the public, hardly a single plate was left intact. No measurements have been made. Towards the end of the jaw it was white, or perhaps it would be better described as of a very light straw color; proceeding backward dark stripes became more and more numerous until ultimately, it was of a uniform dark slate color.

The Skeleton.

This is undoubtedly by far the best specimen of any large whale in America. It is but just short of theoretical perfection. The inferior epiphysis of one ulna was lost during preparation, and there are but sixteen chevron bones, of which some are imperfect. There is no evidence whatever that any others were overlooked or lost subsequently, though such an accident is of course possible. The whale had nearly reached the end of the young stage; the processes are well developed, but all the epiphyses of the fore limb became detached, and all those of the vertebræ except of the fifth caudal and one or two of those nearest the very end of the tail.

The Head.

During the process of preparation the following bones became loosened and were detached: the supramaxillaries, the premaxillaries, the nasals, the jugals, and the lachrymals. Moreover the conjoined petrous and tympanic bones of the right side have been removed; they have not been returned to the skull, but mounted as a separate specimen of the anatomy of the internal ear.

As the following table will show, the proportions of the head correspond very fairly with those given by Mr. Flower, of different heads of the *P. antiquorum* (Proc. Zoo. Soc., 1864, p. 411) and with those of the Rosherville whale. (P. Z. S., 1865, p. 216.)

DIMENSIONS OF HEAD (IN INCHES).

	in.
Length of skull in straight line	144
Breadth of condyles in straight line	11.75
" " " following curve	13.25
" " exoccipitals	44
" " squamosals (greatest breadth of skull)	67
Length of supra-occipital (along curve, just avoiding median spine)	29
" " orbital process of frontal (along lower surface from palatal)	27
Breadth of " " at base	26
" " " " at outer end	16

	in.
Length of nasals (in median line, upper surface)	6
Breadth of the two nasals at posterior end	3.75
" " " " anterior "	9.5
Length of beak	100
" " maxillary (by estimate)	112
Breadth of maxillaries across orbital process (following curve)	71
" " beak at base	50.5
" " " one quarter of length from base	36.5
" " maxillary at same point	12.75
" " premaxillary at same point	5.25
" " beak at middle	28
" " maxillary at same point	9
" " premaxillary at same point	4.25
" " beak at three-quarters length from base	19
" " maxillary at same point	4
" " premaxillary at same point	4
Length of lower jaw in straight line	137.5
Height at coronoid process	17.375
" " middle	10
Amount of curve	15.5

The proportion of the breadth of the skull to the length is a little more than 46.5 per cent., and that of the beak to the length a little less then 19.5 per cent.

Occipital Bone. — The various portions are completely coössified. The Basioccipital is pretty smooth and laterally concave. There is no indication of the point where it joins the basisphenoid. Its greatest breadth is 16 1-2 inches. The condyles, which are separated below merely by a slight groove, diverge as they ascend, so that at the point where they cease to bound the foramen magnum they are four inches apart. The length of a condyle along the curve is 13 inches, the greatest breadth 5 3-4 inches. The Exoccipitals, (Pl. VI, fig. 2 *a*), extend backward and outward, joining the squamous in a deep depression in which the posterior portion of the petrous bone lies. There is a rough tuberosity at about the middle of the posterior border of the exoccipital. The supraoccipital is elongated, which is one of the characteristics of *B. musculus*. The distance from the foramen magnum to the apex of this bone (avoiding the crest on the dorsum) is 28 1-2 inches. About eight inches above the foramen magnum a median longitudinal ridge appears, which reaches nearly to the superior angle. At a few inches from its origin it is very prominent; above, it gradually subsides. On either side, at about the middle of the lateral edge, over the highest point of the parietals, the bone bulges upward into a greater prominence (Pl. VI, fig. 1 *a*) than that of the occipital protuberance. A low, but distinct ridge crosses the middle of the bone transversely through the protuberance, but does not reach the edges. A long swelling (Pl. VI, fig. 1 *b*) moreover, passes upward and outward, describing a curved course from the condyles. It is worthy of note that this part of the occipital bone is marked by very uncommon prominences, particularly for so young an individual.

The Squamous Bone. — This bone may be divided into two parts, viz., an inferior or articular portion (Pl. VI, fig. 2 b), and a superior or temporal one. The former is, in the main, horizontal, and serves for the articulation of the lower jaw, the latter is, in the main, vertical, forming part of the wall of the temporal fossa.

The articular portion, viewed from below, has the form of an expanded concave plate

springing from a comparatively narrow base. It joins the exoccipital above the petrous bone, as already described; its internal edge is then free, till it meets the pterygoid, where it turns at a right angle and ascends, helping to form the external opening of the canal leading from the foramen ovale. The posterior border consists internally of a prominent ridge, which forms the posterior margin of a deep groove anterior to that for the petrous. Further out this groove passes into the upper surface as a large mass projects below it. The anterior border of the articular portion is a smooth vertical plate; towards the outer part of the lower edge there is a tuberosity. The external border is thick and curved. A straight line between its ends measures 27 1-2 inches, one following the superior convexity 41 inches. The superior surface is convex, marked towards its posterior end by several prominences; internally it is overlapped by the supra-occipital. The curve described is greater than I have seen figured in the *B. musculus* and is more like that of the *B. rostrata*.

The temporal portion passes forward from the anterior side of the articular portion. The superior edge is at first covered by the supra-occipital, but its anterior half is separated from it by a thin plate of the parietal. The anterior border of this portion presents two semilunar edges; the upper joins the parietal, the lower the alisphenoid, and the common angle projects between these bones. A very peculiar appearance must now be mentioned; a portion of this bone is in part cut off from the rest by sutures as definite as those separating distinct bones. A suture begins a little below the points of union of the two semilunar edges and runs upward and backward, parallel with the lower horn of the superior half-moon for about 6 inches, where, forming an acute angle with its previous course, it turns directly downward and ends suddenly in a foramen before reaching the lower border. Except in some trifling details this appearance is the same on the two sides.

The Periotic (*or Petrous*) *Bone* (Pl. VI, fig. 2 *c*). — As this bone has been removed from one side of the skull for the purpose of studying the internal ear, its minute description will be given in that connection, and it will here be sufficient to allude to its relations with the surrounding bones.

The bulla is very prominent; its long diameter is directed forward and a little outward The convex aspect faces outward and downward, and the edge of the carina bounds the *foramen lacerum posterius*. The posterior portion is seen pointing outward and backward, tightly wedged in between the squamous and exoccipital. The lower part of the anterior or pyramidal portion is seen as it enters a cavity between the squamous and pterygoid. A little of the labyrinthic portion is also seen in the depths of the fossa.

The Alisphenoid (Pl. VI, fig. 2 *d*). — As much of this bone as is visible from the outside may be divided into three parts, viz., an inferior horizontal portion on the base of the skull, an external one in the temporal fossa, and a pterygoid portion springing in part from each of the others. The inferior portion is about 12 inches long, articulating internally with the vomer. Anteriorly it is overlapped by the palatal, till at the middle of its outer border it bends down to form the internal pterygoid plate; behind, this the border is free. The external portion of the bone is situated in the deepest part of the temporal fossa. It is bounded behind by the squamosal, above and in front by the parietal and the small interposed scale of the basisphenoid. The surface is here concave, but below, as it grows narrower, it becomes convex and makes a bold turn downward and inward forming the external pterygoid plate, which is in contact with the palatal bone anteriorly. The base of

the internal pterygoid plate is separated from the inferior portion of the bone by a longitudinal groove. The plates meet anteriorly at an acute angle under cover of the palatal. They enclose a deep cavity which is bounded below by the hamular process, 4 1-2 inches in length and pointing backward and outward. It assists to form a deep notch with the posterior edge of the external plate. The length of the pterygoid process from the outer opening of the foramen ovale is 8 1-2 inches.

The Parietal. — The surface is concave and forms the greater part of the temporal fossa. The superior border is convex upward and outward. Beginning to follow its course from behind, it is first seen between the squamous and the supra-occipital; at the upper end of the latter it sends a triangular portion inward between it and the frontal (Pl. VI, fig. 1 *c*), which it then begins to overlap. The anterior edge passes backward and downward, turning round the root of the orbital plate. The posterior inferior border is convex and articulates above with the squamous, and lower down with the alisphenoid, from which it is in part separated by the basisphenoid.

The Basisphenoid. — As there is no suture between this bone and the basioccipital, and as the neighboring parts, with the exception of one petrosal, have been quite undisturbed, no description of it would be possible were it not for a small piece visible in the temporal fossa. This piece has been identified as a portion of the basisphenoid from information derived from the works of other observers, for it would be impossible to name it from the little that is seen on the unopened skull. It is about 4 1-2 inches long; its greatest width is 3-4 inch. It is placed nearly horizontally. The posterior end is pretty solid, but the anterior thin and scale-like, and pointing a little downward. It is between the alisphenoid below and the parietal above. In the *B. rostrata*[1] it appears also to touch the squamous, but in this specimen it is separated from it by about three inches. It is remarkably symmetrical on the two sides.

The Frontal. — The bones of the two sides are distinct. The portion nearest the median line is in front of the supra-occipital and of an internal prolongation of the parietal. This part extends forward and outward into a number of delicate laminæ, most of which interdigitate with those of the frontal process of the superior maxilla, but a few internal ones with those of the intermaxilla. A V-shaped cavity in the median line is formed by the two frontals, with a little ridge in the middle for the nasals. Below this the frontal is bounded by the ethmoid, and on the side overlapped by the parietal. The superior border continues free till it reaches the anterior internal angle of the orbital plate, which is hidden by the superior maxillary. This border is 18 inches long. The surface which it bounds is at first vertical, but soon becomes horizontal, forming the supra-orbital plate (Pl. VI, fig. 1 and 2 *e*). This plate is irregularly quadrilateral. The posterior edge bounding the temporal fossa in front is 22 1-4 inches long, reckoning from the parietal. It is thick, and marked by two semilunar depressions, of which the internal is much the larger and very rough. The anterior border is of about the same length, and very thin except at its outer end; it fits more or less accurately into a groove on the upper surface of the maxilla. These two borders converge decidedly, as is characteristic of the *B. musculus*; the anterior is by far the most oblique. The breadth at the base is from 25 to 26 inches; at the outer edge of the plate it is about 16 inches. This end is very thick; it is marked behind by a tuberosity where

[1] Carte and Macalister, Trans. Royal Soc., 1867, p. 201.

it overhangs the squamous, and in front by a smaller one which articulates with the lachrymal. The under side is concave, forming the roof of the orbit. The distance in a straight line between its prominent extremities is 9 inches. The concavity is soon increased into a groove which runs into a canal representing the continuation of the optic foramen (Pl. VI, fig. 2 *f*). This forms a prominent ridge along the posterior border of the inferior aspect of the orbital plate. The greater part of the remainder of this surface of the plate is hidden by the superior maxillary. There is a depression towards the base.

The Ethmoid.— This bone is not easily studied owing to its position, and has in this case suffered a good deal on account of its softness. It probably was never very distinct from the rostral cartilage. There is now to be seen an irregular crumbling bone, filling the posterior end of the cavity between the plates of the vomer. A plate passes upward from either side to meet its fellow in the middle, on the under surface of the frontal. This may perhaps be considered the orbital surface, though it is very deeply placed. In the *B. rostrata* (loc. cit.) it is said to reach as far back as the pterygoid bone; in this case it does not approach it. At the junction of these plates the bone spreads out laterally for a short distance, supporting the frontal.

The Vomer (Pl. VI, fig. 1 *f*, fig. 2 *g*). — The vomer consists of a horizontal portion fitting on to the base of the skull, and of two plates forming the rostrum. The former portion rests on the basisphenoid, and curves downward on either side to meet the internal edge of the pterygoids. It is most expanded at the posterior end, measuring 10 1-2 inches in a straight line between the angles. It begins to contract almost at once, but expands in front of the pterygoids to meet the palatals; still more anteriorly it bends upward and joins the frontals. A little more than an inch in front of the posterior edge a median ridge begins to appear, which soon becomes prominent, and sweeps boldly downward to form the beginning of the rostrum. Towards the end of its course it turns suddenly backward, so that the spine of the rostrum overhangs its posterior edge. The entire length of the vomer is 10 feet 1 inch, that of the spine of the rostrum 9 feet. The two plates meet at first at a very acute angle, which becomes more obtuse towards the apex. The greatest depth of the bone is in the neighborhood of the anterior end of the palatals, where it amounts to 13 inches. The superior edges of the plates, at first thin, become thick in the nasal region where they articulate with the superior maxillaries, but become anteriorly very thin and scale-like.

Palatal Bone (Pl. VI, fig. 2 *h*). — This bone consists of a thin plate lying on the outer side of the vomer. The posterior end is the most solid part and articulates with the anterior edge of the pterygoid; it reaches superiorly into the angle between that bone and the frontal, and then expands on the under surface of the latter. From the lower end of the pterygoid the border passes inward to meet the projecting spine at the beginning of the rostrum of the vomer. The remainder of the lower border measures nearly 26 inches. On reaching the supramaxillary the border turns upward and passes into the superior one by a rounded angle. The anterior part of the superior border is marked by a deep groove for the maxilla. Near the posterior superior angle there is also a slight groove passing downward and backward with an elevation below it.

Superior Maxilla (Pl. VI. fig. 1 *g*, fig. 2 *i*). — This is best considered as a pyramid with a superior, an internal, an inferior surface and a hollowed base for its posterior attachment. The greatest length is 9 feet, to which about 2 inches may be added owing to injury of the

point. *The superior surface* is convex both longitudinally and laterally. It is bounded behind by a curved ridge, concave backward, which connects the nasal and zygomatic processes, and which overhangs the anterior internal angle of the orbital plate. The nasal process is the continuation of the internal part of this surface. It begins so gradually that the length cannot be given; at its posterior end it is 5 inches broad. Below its smooth upper surface it consists of a number of very delicate plates to articulate with others from the frontal. The zygomatic process is directed outward, downward and backward. The outer border runs in a straight line to the tip, but the internal is concave towards its posterior end, so as to increase the breadth of the nasal opening. This upper surface is marked by seven foramina on the left bone, and twelve on the right; the latter, however, are smaller. They present no regularity except in opening forward and outward, and in being confined to less than the posterior half of the bone.

The internal surface is nearly at right angles with the superior, and is also triangular. Posteriorly it runs into the nasal process; below and in front of which it forms part of the wall of the nasal cavity, in which it begins to bear a prominent longitudinal ridge which overlaps the lateral plate of the vomer, and is soon included between that and the intermaxillary. The lower part of the posterior border shows a curve corresponding to the anterior convexity of the palate bone. *The inferior surface* may be said to be concave in all directions; it is marked by some twenty-four foramina and grooves; though very irregular these may be divided into two classes, the first consists chiefly of grooves running forward along the median or vertical part of this surface, the second forms part of a circle of foramina, pointing towards the periphery of the bone. They are in places arranged in a double row, one opening just internal to the other. The internal posterior angle is free, hanging under the orbital plate of the frontal, and a little external to the palatal; the posterior edge is irregular in outline; just before reaching the outer angle it presents a small concavity with which the jugal articulates very accurately. The concave *base*, quite hidden when the bone is in place, does not require a minute description, its chief peculiarity consists in the large foramina communicating for the most part with one another, by which the canals begin which convey the nerves and vessels to the various openings already mentioned.

The Intermaxillary (Pl. VI, fig. 1 *h*, fig. 2 *j*). — Greatest length 8 feet 11 inches, with about one inch to restore. For about the anterior three-fourths of its length it presents three surfaces and three borders. The superior is smooth and of denser structure than the others; it forms a continuous surface with the superior maxillary; the external surface is in apposition with that bone and is in no way peculiar. The internal and inferior is concave. At about two-thirds of the length of the bone from before, the edges cease to be sharply defined, and the bone becomes thin and twisted upon itself in such a manner that the superior surface becomes the internal, forming the outer wall of the nasal cavity. At its extremity the bone ends in a few vertical scaly plates, which interdigitate with others from the frontal.

The Nasal (Pl. VI, fig. 1 *i*). — This is a wedge-shaped bone with a concave base and a blunted edge. The thin end which is directed backwards is rough to articulate with the frontal. The internal surface, which is in apposition with that of the other bone, is smooth, but marked by some curved lines running downward and forward. The outer surface is received into a depression chiefly in the frontal, but in part in the intermaxillary. Its

upper and lower borders converge. It ends in two prolongations, of which the superior rests on the intermaxillary bone, and the inferior, which is longer, reaches almost to the maxillary — very possibly quite to it in the fresh state. The anterior surface is concave from side to side, being inclosed by the median and lateral prominences. It becomes narrow as it turns on to the upper surface, and passes to the outside of a median triangular elevation. The under surface is smooth and bounded anteriorly by an oblique line running forward and inward. When the two nasals are in position they form a prominent spine in the median line.

The greatest height (*i. e.*, vertical length) taken near the posterior end is 10 1-2 inches. The other dimensions can be found in the table of measurements.

The Malar (Pl. VI, fig. 2 *k*). — This is a thin bone; broad in front, narrow behind; concave above, convex below. The lower surface is marked near its anterior end by a wavy ridge which articulates with the posterior border of the superior maxillary. On front of this ridge the malar is thinner and overlaps the adjoining bone. The upper surface bears at its anterior extremity a depression for union with the lachrymal. The outer edge is thick; the inner thin. Towards the front of the outer border there is a deep notch, the continuation of a groove on the upper surface. The greatest length of the bone is 9 3-4 inches; It ends behind in a spine 3-4 inch long, pointing directly inward.

The Lachrymal (Pl. VI, fig. 2 *l*) is in shape an oblique parallelogram with rounded angles, placed transversely between the frontal and the outer angle of the superior maxilla. It helps to form the orbit anteriorly. Only a very small portion projects outwards. The inferior surface presents a depression for articulation with the malar.

The Mandible. — The lower jaw is very solid and heavy. It is strongly curved, the greatest convexity being rather behind the middle. The head, which forms the posterior end of the bone, is of ovoid shape, with the long diameter running downward and outward. It is separated from the body by a groove running outward and a little downward on the hinder aspect. The neck is constricted laterally, but the sides retain their convex form. It is marked below by a rough line, above by a sharp ridge which runs forward and turning downward forms the edge of the roof of the dental canal, overhanging the entrance. The coronoid process extends upward and outward and ends in a blunt knob. Its posterior border is nearly vertical, its anterior is very oblique, and gradually subsiding forms the superior division between the outer and inner surfaces. The body decreases in size very gradually; the outer surface is convex, the inner nearly plane, except near the anterior end where its upper portion overhangs the inferior, forming a groove. The opening of the dental canal is situated a little behind a line dropped from the posterior border of the coronoid. A groove containing many small foramina runs along the upper part of the internal surface, just inside of the bounding line. Several larger foramina are placed in a row on the upper part of the convex outer surface. These latter are eight in number on the left side, and eleven on the right.

Hyoid.— The basihyal with the coössified thyro-hyals presents the appearance characteristic of the species. The body is nearly flat, and the thyro-hyals, at first very solid, taper towards the end and are bent strongly upward. The anterior cornua which surmount the body are nearly two inches long, and but about half an inch apart. There is a median notch on the posterior border of the body with a slight tuberosity on either side. Its superior surface is deeply grooved in the middle. The antero-posterior diameter of the body in

the median line is 4 3-4 inches. In a straight line between the ends the bone is 24 1-2 inches broad; following the convexity 31 inches. The circumference of the thyro-hyal at its extremity is 7 inches, and midway between this point and the centre of the bone 11 1-4 inches.

The Stylo Hyal.—This is 15 inches long in a straight line, and 16 inches following the convexity. It is compressed above and below, except at the very inner end where the vertical diameter is the greatest. The outer end is but 1 inch thick.

Vertebræ.

The vertebral formula is 7 cervical, 15 dorsal, 15 lumbar, 26 caudal. As the cervical vertebræ are always described as of particular importance for classification in spite of the considerable variations which they exhibit, it is advisable to describe each one separately, so that accurate comparisons can be drawn between corresponding bones in different skeletons. The vertebræ of the other regions will be considered in a different manner.

Atlas.—This bone, like that of the Rosherville specimen described by Mr. Murie (P. Z. S., 1865, p. 217), resembles Gray's figure of the atlas of the *P. Duguidii* rather more closely than that of the *P. antiquorum* in the thickness and obtuseness of the transverse processes, the greater length of the neural spine and the greater interval between the inferior ends of the anterior articular surfaces. The anterior aspect is formed by the articular surfaces and the transverse processes. The greatest length of the articular surfaces is 10 1-4 inches, the greatest breadth 5 1-4 inches; they are deeply concave and surrounded by a slight groove, separating them from the outer aspects of the bone. The superior extremities of these cavities are 5 inches apart; the inferior 3-4 inch. The opening between them is 7 1-4 inches long; it becomes constricted about the middle, the superior half forming the continuation of the spinal canal, the inferior being closed by the body of the axis.

The posterior surface presents the same general outline, but the two articular surfaces are united into one by an isthmus 1 1-2 inches in breadth, across the inferior part of the bone. They do not form the lateral boundaries of the canal, but are separated from it by about 1 inch of smooth bone. The arch is marked above by a longitudinal spine in the median line with a prominence at either end. The anterior border is sharp, but presents a tubercle at the point of union with the articular surfaces, which forms the roof of a canal opening directly external to it (Pl. vi, fig. 4 *a*). The lower edge of the arch is thick and presents a smooth surface (Pl. vi, fig. 4 *b*) on each side of the median line for articulation with corresponding ones on the arch of the axis in serial homology with the zygapophyses. There is a slight prominence projecting backward in the median line. The tranverse process has a broad vertical base from which it gradually tapers. Towards its point it is twisted upon itself so that the anterior surface of the base becomes the inferior near the apex, and the posterior in like manner becomes the superior. On the superior aspect of the bone the tranverse process springs from a prominent tubercle (Pl. vi, fig. 3 *a*, fig. 4 *c*) on the posterior border. Nutrient foramina enter the bone on the front and back of the base of the transverse process.

Axis.—The Boston whale, unlike the Rosherville one, resembles in this point the drawing of the *P. Duguidii* and not that of the *P. antiquorum*; Gray's drawing of the former

would almost answer for this case were it not for the greater depression which the Boston whale presents in the inferior surface, and for a slight difference in the external border of the lateral portions. The anterior surface has an articular portion of the usual shape corresponding to that on the posterior side of the atlas. The odontoid process (Pl. VI, fig. 5 *a*), is about 1-2 inch in height, and presents a depression in its summit like the crater of a volcano. The posterior surface has a deep vertical depression in the middle, which is continued into a notch in the upper and lower sides. The two halves of the body share in the inclination of the transverse processes; these are broad masses enclosing a large foramen 5 1-2 inches on the left side, 4 1-8 inches on the right, which shows of how little value such features are for classification. The parapophysis, which forms the inferior boundary, is broader and stouter than the diapophysis, which forms the upper. The transverse processes are directed backward, as shown in fig. 7. Two tuberosities forward inclining, of which the internal is the larger, separated by a slight groove, are seen on the superior edge of the diapophysis over the foramen (Pl. VI, fig. 5 *b*). The spinal canal has a breadth of 5 1-8 inches to a height of 4 1-2. The arch presents a slight ridge in the median line, and a prominence on either side projecting forward and upward; that on the right is the larger. On the anterior aspect of each of these prominences is a smooth plate (Pl. VI, fig. 5 *c*), the real zygapophysis; the posterior ones (Pl. VI, fig. 6 *a*) are on the outer sides of the arch.

The other cervical vertebræ show the usual amount of individual variation when compared with descriptions and figures. The rings formed by the transverse processes are complete in the 4th or 5th, and very nearly in the 3d. In the latter the interval is of only about 1-4 inch on the right side; on the left it cannot be accurately determined, as a small piece has been broken off. In the 6th the inferior processes are very small, that of the left side, however, being more than twice as large as its fellow. They exist in the 7th only as slight ridges. After this description of the first two and slight sketch of the remaining cervical vertebræ, it appears well to study in connection with the following table of measurements the modifications which each element of a vertebra undergoes in the entire column, and to compare them with those in other specimens.

Vertebræ.	Greatest width between extreme points of transverse processes.	Greatest height of body and neural spine.	Greatest width of body.	Greatest height of body (in median line).	Greatest length of body.	Breadth of transverse processes near tip (antero post.).	Breadth of neural spine near tip.	Distance between anterior points of metapophyses.
Cervical.								
1	21	12	12.5		4.25	2.5	4.5	
2	29.25	12	12.5	6.5	3		2.75	
3	25.87	11	11	6.5	1.87		2.5	
4	26.12	11.25	10.75	7	1.75		2.12	
5	26.25	11	10.75	7.12	1.75	.25	1.87	
6	25.25	11.37	10.5	7.5	2	.37	2	
7	26.25	12.37	10.5	7.5	2.25	1	2.5	
Dorsal.								
1	26	12.37	10.75	7.5	3	1.5	1	10.5
2	24.25	13.37	10.75	7.37	3.5	2	1.5	11
3	24	14.75	11	7.12	4.25	4.25	3.25	10.75
4	26	17	10.75	7.25	5.12	5.75	5	9
5	28	18	10.37	7.25	5.62	6.5	5.75	7
6	29.25	18.75	10.25	7.25	6	6.5	6	4.75
7	30.62	19.75	10	7.25	6.25	6.5	6	4

Vertebræ.	Greatest width between extreme points of transverse processes.	Greatest height of body and neural spine.	Greatest width of body.	Greatest height of body (in median line).	Greatest length of body.	Breadth of transverse processes near tip (antero post.).	Breadth of neural spine near tip.	Distance between anterior points of metapophyses.
Dorsal.								
8	31.25	20.5	10	7.5	6.75	6.75	6.75	3.25
9	31.5	21.25	10.25	7.5	6.75	6.5	6.62	3.62
10	31.5	21.62	10.25	7.75	6.87	6	6.62	3.25
11	32.5	22.12	10.37	8	7	6.25	6.37	3.12
12	33	22.25	10.25	8.12	7	6.25	6.5	3
13	33.75	22.5	10.25	8.25	7	6.5	6.62	2.87
14	34.5	22.75	10.25	8	7.25	6.5	7.37	2.62
15	34.12	23	10.25	8.62	7.5	5	7.5	2.5*
Lumbar.								
1	33.75	23.25	10.5	8.5	7.5	5.75	6	2.75
2	34	23.5	10.5	8.5	7.5	6.12	6.25	2.75*
3	35	23.62	10.75	8.75	7.75	7.37	6.5	2.75
4	34.75	24	10.75	9	7.87	7	6.62	2.75
5	34.25	24.5	10.75	9	7.75	6.75	6.25	2.75
6	33.62	24.75	10.75	9	8	7.25	6	2.87
7	33.75	24.12	10.75	9	7.87	6.87	7	2.62
8	32.62	24.87	10.75	9	8.25	6.75	7	2.87
9	32.62	25	11	9	8.12	6.75	6.5	2.75
10	31.75	25	11	9.25	8.25	6.75	7.37	2.87
11	30.62	25	11	9.25	8.25	6.87	7.5	2.87
12	29.25	25.12	11.25	9.5	8.75	6.75	7.12	3
13	27.5	24.87	11.5	9.5	9	6.12	7.12	3.25
14	26.5	24.75	11.5	9.62	9	6	6.87	3.12
15	25	24.25	11.5	9.5	9.25	7.12	6.62	3.62
Caudal.								
1	23.25	24.25	11.75	9.75	9.25	6.5	6.75	4.25
2	22.37	24	11.5	10	9.25	5	6.37	3.87
3	21.5	23.25	11.75	10.12	9.12	4.5	6.25	3.5
4	20.75	21.5	11.5	10.25	9.25	4.25	5.62	3.75
5	19.62	19.87	11.75	10.5	9.37	4.5	4.25	4.5
6	17.75	18.25	11.5	10.12	9.5	4.12	3*	3*
7	16.75	17.5	11.75	10.25	9.37	4.37	2.62	3*
8	15.25	17	11.75	10.25	9.25	4.87	2.5	3.62
9	14	15.5	11.5	10.12	9.12	5	2	3
10	12.87	13.87	10.75	10	9	4.75	1.75	1.5
11	11.87	14	10.62	10	8.75	2.5	2.25	1.5
12	11	13.12	10	9.75	8.5	2.25	2	1.75
13	9.62	11.37*	9.37	9.25	8.12	1.5*	1.75	1.25
14	9.25	10.62	8.62	9	7.25		2	1
15	7.37	9	7.37	7.25	5.25		1.25	
16	6.75	6.75	6.75	6.75	4			
17	5.75	5.87	5.75	5.87	3.62			
18	5.12	5.25	5.12	5.25	3.37			
19	4.37	4.37	4.37	4.37	3.12			
20	3.75	3.62	3.75	3.62	2.87			
21	3.25	3.25	3.25	3.25	2.5			
22	2.5	2.5	2.5	2.5	2			
23	2.12	1.87	2.12	1.87	1.62			
24	1.25	1.5	1.25	1.5	1.37			
25	1.25	1	1.25	1	1			
26	.87	.87	.87	.87	.62			

The Bodies. — In the axis the two lateral halves of the body are symmetrically bent backward. The 3d, 4th, and 5th vertebræ present a similar appearance; the last, however, very slightly. In all the others the ends are about plane, till the 13th caudal, which

* The star indicates that some point of the vertebra is slightly injured, so that an *absolutely* accurate measurement could not be made.

has a slight central depression on its posterior extremity. This depression becomes more marked in the succeeding ones, and after the 16th a similar one is seen on the anterior extremity. The 23d is convex posteriorly, and the three remaining are too evidently irregular to deserve description. The 3d cervical presents a depression in the upper and lower border, which is marked by a prominence in the median line, that below being double, but single in those following. In the 4th the depressions are very slight, and in the 5th are wanting. The superior median prominence continues throughout the cervicals, though gradually decreasing; the inferior becomes more marked, and in and after the 4th dorsal is very striking, showing a prominent longitudinal ridge. In the 5th, 6th, and 7th it gradually disappears, but returns in the 13th, and increases till it attains its greatest development at about the middle of the lumbar region. In the 15th lumbar it shows signs of bifurcation towards the posterior end. In the 1st caudal these prominences become marked for the attachment of the chevron bones, and we now have two lines with a median depression between them. In the 4th caudal lesser prominences appear at the anterior end. The depression continues to grow deeper, and as the bodies become shorter the elevations on the ends of these lines are naturally brought nearer together, till in the 13th they unite, forming a ridge perforated by a foramen corresponding to the previously existing notch In the 15th the bone has become so much modified that there is merely a single protuberance on either side of the foramina which enter the inferior surface of the bone, and presently this disappears entirely. The superior surface of the body forming the floor of the spinal canal loses, as already stated, the central ridge with the first dorsal vertebræ, and after that is marked by a concavity in its centre, its anterior and posterior borders remaining straight. This concavity is most marked about the middle of the dorsal region. The proportions of the bodies can be seen by reference to the table. At first they are broad and thin in the cervical, but later the height and length increase, till in the anterior caudal region the three diameters are not very different. In the 14th caudal the height for the first time surpasses the breadth. In the 15th dorsal the length approaches to within 1-4 of an inch of the height, but as the latter then increases the discrepancy continues till we reach the 23d caudal. These proportions agree very well with those to be deduced from

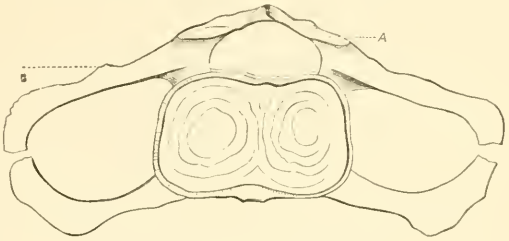


Fig. 3. — 3d Cervical Vertebra.

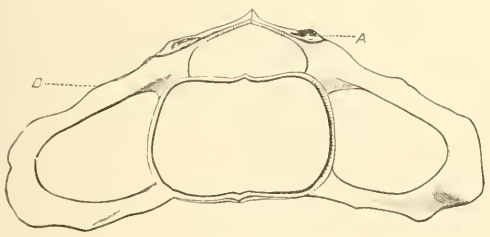


Fig. 4. — 4th Cervical Vertebra.

Mr. Murie's table in the case of the Rosherville whale. I do not remember any account of the aortic impression in the whale; in this one, however, it is very striking. As the inferior surfaces of the body are more or less concave with prominent borders, it is in the outline of the epiphyses that this depression is most evident. The 10th dorsal vertebra is the first in which it is distinct, though there is a suspicion of it in the 8th and 9th. It becomes more developed in the 11th, 12th, and 13th, after which in the 14th and 15th it quite destroys the symmetry of the bone, forming a depression along the left side of the body. It is less marked in the 1st lumbar and barely perceptible in the 2d, after which there is no trace of it.

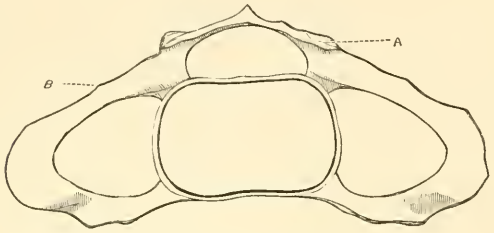


Fig. 5. — 5th Cervical Vertebra.

The foramina being in a great degree dependent upon modifications of the processes, will be considered separately, as will be also the last few vertebræ.

Spinous Processes. — These processes are represented by mere ridges in the cervical vertebræ, except the 7th, where there is a decided elevation. In the 3d dorsal it is very much larger and broader than in the 2d, and the 4th presents even a greater increase. After this the difference is less. In the 8th dorsal a slight backward inclination is manifest, which increases with the height (reckoning with the latter that of the body of the vertebra), till both reach their maximum in the 12th and 13th lumbar. Beyond this point the height rapidly decreases, though a considerable inclination persists. The 14th caudal is the last vertebra which can be said to have a spinous process. The processes are more or less rounded at the top, and the measurements in the 7th column of the table are taken just below the termination, so as in most cases to give the greatest breadth (antero-posteriorly). In the 5th dorsal a posteriorly projecting spine arises from the base of the process, entering the space between the metapophyses of the following vertebræ. This is at first double, being in serial continuation with the posterior zygapophysis. The bifurcation grows less marked, and ceases near the end of the lumbars; the spine persists till we reach the 5th caudal, attaining its greatest size towards the posterior end of the lumbar division. To compare this table with Mr. Murie's, it is found that the height of the entire vertebra is with us greatest in the 12th lumbar, though about the same in several adjacent vertebra, while in his table the 1st caudal springs into sudden prëeminence. As to the breadth toward the point of the process it is greatest with us in the 10th lumbar, with him in the 6th lumbar.

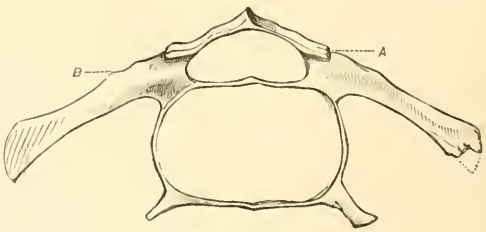


Fig. 6. — 6th Cervical Vertebra.

Transverse Processes (*Diapophyses*). — The inferior transverse processes (parapophyses)

in the cervical region have already been sufficiently mentioned. The great lateral masses of the axis incline strongly backward, particularly towards the upper surface. The processes of the 3d and 4th cervicals have the same inclination to a lesser degree; those of the 5th are about straight, and those of the 6th and 7th incline forward so that the extremities of the transverse processes from the 2d to the 7th cervical very nearly touch one another. All these processes, except the 7th, are exceedingly thin, and that of the 3d dorsal is the first in which the thickness is greater than the height; all the subsequent ones are thin and compressed from above downward. The thin superior edges of the cervical transverse processes present each a small, rough elevation (*B* in woodcuts,) at some distance from the body, which are serially homologous, with a similar projection from the axis. In the 2d and 3d cervicals the transverse processes spring almost entirely from the pedicles, but in the following vertebræ they arise more and more from the bodies. In the first six dorsals the origin is very extensive, for though they really arise from the bodies, the line forming the posterior superior border runs up into the arch. In the 7th dorsal this line disappears and they continue to arise successively lower. In the 5th caudal they arise from a point a little below the centre of the body; in some of the subsequent ones perhaps a little higher, though not above the centre.

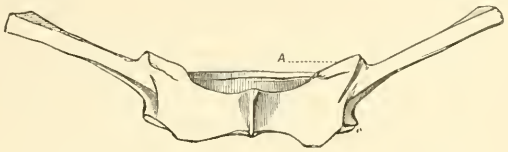


Fig. 7. — 7th Cervical Vertebra.

With regard to shape and direction the first five dorsals incline forward like the latter cervical vertebra; a few are then about straight, after which a slight backward tendency appears. In the 5th dorsal an angle appears in the anterior border and the part external to this is directed backward; this persists throughout the dorsals, and reappears from the 9th lumbar to the 4th caudal. The general backward inclination ends with the anterior lumbars, and after a few vertebræ a forward one is substituted which continues to the end. In the 8th caudal the base becomes long and perforated, and persists so till the 14th, with which the transverse process ceases to exist. The greatest distance between the extremities of the transverse processes of a vertebra occurs in the 2d lumbar, with Mr. Murie in the 4th. The ends of these processes are hollowed in the dorsal region for the tubercles of the ribs. The depression in the first two is at the end, but subsequent ones are hollowed below. The fossa is very deep in the 4th, 5th, and 6th, bounded anteriorly by an oblique ridge which ends internally in a sharp point. The posterior fossæ are less and less

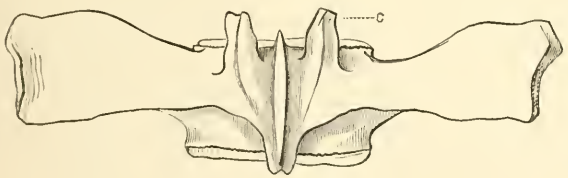


Fig. 8. — 6th Dorsal Vertebra.

marked, and leave the under side of the bone to get on to the posterior corner of the end of the transverse process.

Articulating Processes (*Zygapophyses*). (*A* in woodcuts.) — These are found in the cervical and more or less plainly in the first five dorsal vertebræ. In the 3d cervical the anterior zygapophysis is an oval, smooth surface placed on the outer end of the arch by the origin of the diapophysis, having its long diameter transverse. In the succeeding vertebræ it gradually changes its position so that the long diameter points forward and outward. The surface begins to face inward with the first dorsal. In the 4th, this surface is on the inner side of the metapophyses facing directly inward. In the 5th, it is largely perceptible. The posterior zygapophyses, more or less convex, follow the variations of the anterior ones, though of course in an inverted direction. Those of the anterior vertebræ face backward, those of the posterior outward. They of course get nearer together. It is important to observe that the series of the zygapophyses is continued on to the anterior side of the arch of the axis and to the posterior side of the arch of the atlas. The surfaces on the latter almost meet in the median line. The zygapophyses are clearly continued towards the tail, as the projections at the base of the spinous process already mentioned.

The metapophyses (*C* in cut) are first seen unmistakably in the second dorsal, where a slender pointed process projects forward on either side from the base of the transverse process, a little external to the zygapophysis. In the first dorsal we must hold that this process does not exist, or that it is represented by a small protuberance on the upper edge of the transverse process which is the last of a series already mentioned in the cervical vertebræ, beginning very prominently on the axis. I shall not attempt to decide whether these are to be considered metapophyses, but simply suggest the question. In the 3d dorsal the metapophyses are thicker and continuous with the outer side of the articular surfaces. Those of the two sides now rapidly become closer together, and instead of springing from the base of the transverse process, they soon spring from the base of the spinous, and they appear as two vertical, quadrilateral plates parallel to one another. With the 6th lumbar, the vertical anterior edge begins to be cut away below, and this increasing, they appear nearly triangular. Among the last few lumbars, these plates cease to be parallel, each bending a little outward; this change increases rapidly and in the 6th caudal they are expanded and nearly horizontal. After this they rapidly decrease in size, appearing only as knobs projecting upward and outward, and with the 15th they disappear.

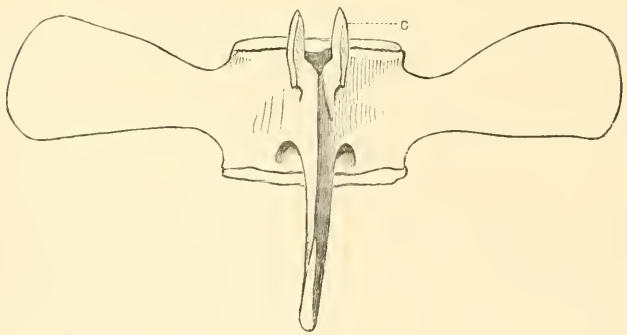


Fig. 9. — 6th Lumbar Vertebra.

Foramina. — The nutritive foramina of the atlas have been noticed. The principal seats of these foramina in the majority of vertebræ are towards the ends of the body, near the root of the transverse processes, and on the upper and lower surfaces of the body near the middle. In the dorsal region the superior foramina are usually two, symmetrically placed side by side, and this arrangement continues with occasional variations. On the lower surface a similar arrangement begins to prevail towards the posterior end of the lumbar region. In the 7th caudal, the anterior edge of the transverse process presents a deep notch; in the 8th its base is broad and perforated by a foramen which continues until all trace of a transverse process is lost in the 14th, after that, one or more foramina in a corresponding position are visible entering the bone, till the last two or three are reached. In the 13th and 14th caudal, the projections at the ends of the vertebra for the chevron bones become united into ridges with a central perforation. Subsequently two proportionally large foramina appear side by side, entering the bone, and persist till the last three. It is very probable, reasoning from analogy, that the perforations of the transverse processes are for vessels, because after these processes have ceased to exist I have found that a wire passed into one of the inferior foramina emerges through the lateral one and if it be then thrust in again can be brought out above. The inferior foramina continue close together, those above become more or less separated; but the communication with slight variations continues the same.

The Spinal Canal. — The vertical and transverse diameters of this canal are about equal in the first two vertebræ; in the remaining cervical the transverse greatly exceeds the other. In the 2d and 3d dorsal the height of the canal increases considerably, and in the 5th, the two diameters are about equal. Shortly afterwards the vertical prevails and the next change is the shortening of the transverse. The last dorsal presents a canal having the form of an isosceles triangle, which continues about the same through the lumbar region. Towards the beginning of the caudal region it becomes smaller, in the 15th it is barely pervious, and in the 16th does not exist.

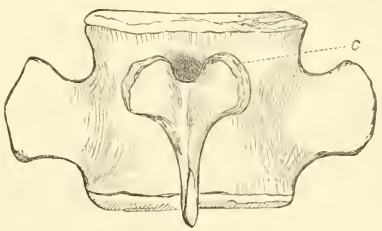


Fig. 10.— 6th Caudal Vertebra.

From this description and a study of the table, the shape of any given vertebra may be pretty accurately deduced, but some further account of the latter part of the caudal region may be convenient. The 15th caudal is a transition from the vertebræ bearing processes to those bearing none. It is the last showing any sign of a spinal canal, which here is so small that one end will not admit the little finger. It is covered by a bridge of bone which shows no signs of a spinous process or of metapophyses. The transverse processes had disappeared in a previous vertebra. The inferior processes for the chevron bones are two mere swellings without the perforation shown in the 13th and 14th. The 16th is about round, without any striking characteristic. The 17th looks rather square and the succeeding ones are decidedly so; they have two foramina close together, on the lower side and two above at some distance apart. The 24th and 25th show a want of regularity and of anything characteristic. The 26th (Pl. VI, fig. 8), the last, tapers towards its posterior end, which

bears a small projecting epiphysis which gives a peculiar finish to the spinal column. The adjacent epiphyses of this vertebra and the preceding one, are grown into one plate about 3-8 of an inch thick, which is nearly smooth on its posterior aspect, but on its anterior presents a central spine which fits into a depression in the 25th.

The Chevron Bones.

These constitute the only part of the skeleton which is not in a satisfactory condition. At the time of the dissection they were so soft that some were cut completely in two by the workmen before they were thought of. There are parts of sixteen bones, but one lateral half of the first and last are wanting, and some others are more or less mutilated so that the correctness of the arrangement which has been adopted is not quite certain. The two sides of the 1st, 15th and 16th had not yet united. The 1st is a thin plate slightly convex on its outer side with an articular surface on the upper end; the inferior end is drawn out backward. The articular surface of the 2d and 3d is also single, after which this surface is divided into two by a transverse ridge till the 11th. The bases become wider transversely in proportion to the size of the bones as we pass backward. The plate forming the arch is constricted at the upper part in the anterior ones (except the first), but becomes broad after the first few. The lower end projects both forward and backward, chiefly in the latter direction. I have not been able to find any regular proportion between the size and the position of these bones.

The following table shows the greatest vertical and longitudinal (from before backward) diameters in inches.

Number of Bone.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Height.	6	8.75	9	8.5	8.25	7.5	8.25	8.75	7	7	6.5	5.5	4.5	3	1.75	1
Length.	3.25	6	6.75	7	6*	6.5	6.5	5.5*	5.75		5.5	5.75	5.5	4	2.25	1.25

Those marked with stars have a little wanting. About a third part of the 10th is wanting.

One peculiarity in the formation of these bones deserves particular notice. They are formed in two lateral pieces which appear to have been put together unevenly, that is one a little in front of the other; thus the anterior edge of one plate is continued directly on the anterior edge of the spine formed by the union of the two, while the front edge of the other falls a little back of it; on the other hand, the posterior edge of the second projects behind that of the first. This appearance is present in all the bones excepting two, both of which are imperfect at important points. The plate on the left side is (with one exception) the anterior one. In most of the larger ones the keel, instead of being in the median line, is somewhat deflected to the right, and the left side of the bone shows a slight concavity suggestive of the depression which would be caused by a large artery.

The Ribs.

The following descriptions and measurements are taken from the ribs of the left side; those of the right present some curious pathological alterations and will be considered later.

There are fifteen pairs of ribs articulated by their tubercles to the ends of the transverse processes of the dorsal vertebræ. The head and neck are well developed only in the

second and third. The first rib is flat and broad, the tubercle turns downward, presents a small articular surface and sends inward a slight prominence representing the head and neck. The angle is marked by an elevation which bends forward; the space between it and the tubercle is convex in front and concave behind, which is the case also in the succeeding ribs. The second rib has on the tubercle a narrow articular surface 4 1-2 inches long. The neck is slender, 4 1-2 inches long and terminates in a small knob for the head. The angle bears a prominence which, unlike that of the first rib, bends backward. The third rib is longer, but the head and neck measure only 3 inches. The angle is more prominent. The neck of the fourth rib is indicated by a very slight prominence. In the subsequent ribs there is no sign of it. The fifth and sixth resemble each other very closely. The latter is the longer one, and the angular prominence is less well marked. There is but a very slight downward projection from the articular tubercle. The succeeding ribs present a similar gradual change; the prominence at the angle is less and less, so as to be hardly perceptible in the 12th. The ribs become narrower and the articulating surface shorter and broader, so that the extremity of each of the four ribs preceding the last is almost globular; in the fifteenth, however, it is oblong. This rib is flat, compressed above and below, and extending directly outward from the vertebral column for 7 or 8 inches, when, becoming narrower, it turns upon itself and points backward and downward, with an external and an internal surface. It has, properly speaking, no angle. The eleventh and twelth ribs present a small prominence on the posterior superior border, apparently for muscular attachment.

The following table gives the greatest length of each rib along the convexity, the distance between the ends in a straight line; and, to show the amount of curvature, the greatest distance from a straight line to the inner surface of the bone. (The measurements are in inches.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Greatest length.	41	64	70.75	74.5	73.25	75	74.25	71.5	67.75	63.25	59.5	53.5	48	46	47.5
Length in a straight line.	33.5	37.5	47.5	52.75	56	57.25	58.25	54.75	53	51.5	49.25	46.25	44	43.5	45.5
Amount of curve.	8	12.25	14.25	14.25	16	16	16.25	15.75	14.5	13.25	11.5	8.75	5.25	5.25	6.25

On comparing the heads and necks of the first four ribs with the woodcuts of those of the Rosherville skeleton, it is plain that those of this whale are much more developed. The third, though less developed than the second, is as much so as the second of the Rosherville.

The ribs of the right side. — The first five offer no peculiarity. The tubercle of the sixth is rather heavier than that of the other side, and the tuberosity at the angle very much so. A little external to the angle a rough prominence about 8 inches long projects boldly from the upper part of the rib, giving very strongly the appearance of a repaired fracture; the continuity of the inferior edge, however, is perfect. The seventh bears a corresponding, but less marked prominence. The tubercle of this rib is very rough and irregular, as if by the effects of inflammation. It is of double thickness, owing to the projection of an irregular mass from its posterior aspect. The tubercles of the eighth and ninth have similar malformations, but in a less and decreasing degree. The shafts are regular. The succeeding ribs are normal, till the fifteenth, which is a fine specimen of an ununited fracture. The proximal fragment, 14 inches long, corresponds with a like extent of the rib of the opposite side, except in being on a smaller scale and in running gradually to a point.

The second piece, 33 1-2 inches in length, begins above by a sharp extremity, which is considerably bent upon the rest of the bone and points inward. As it grows broader a a small spine appears on either side, after which the bone gradually assumes a normal appearance. These fragments were firmly united by ligamentous structures. The ends exhibit the signs of atrophy rather than any attempt towards reparation.

The Sternum. Plate vi, fig. 10.

This bone is very porous and has suffered some injuries, particularly in the upper and outer part of the right side. It resembles very closely the sternum of the whale in Alexandra Park, figured by Mr. Flower [Proc. Zool. Soc., 1864, p. 393]; but the posterior process is not so long. The only peculiarity of the bone in this specimen is its asymmetry. The inferior surface is, as usual, convex laterally and concave antero-posteriorly. The posterior projection is curved very much to the right, and, to increase the distortion, the lateral projection of the right side bends a little downward and that of the left a little upward. The former of these lateral processes appears to have been originally shorter than the other, but it is impossible to say accurately how much is wanting.

Greatest length in a straight line	12.75 in.	Without any restoration.
" breadth " "	15.75 "	

Anterior Extremity.

Scapula. — This bone agrees very closely with the one figured by Gervais and Van Beneden, except that the outer surface appears more plane.

MEASUREMENTS.

Length of superior border (following curve)	42.37 in.
" in straight line from the posterior superior to anterior superior angle	34.75 "
Greatest height from about middle of glenoid cavity	20.62 "
Length of anterior border to origin of coracoid (in straight line)	15.62 "
" posterior border to back of glenoid cavity	16.75 "
Circumference of neck	23.62 "
Length of glenoid cavity to root of coracoid	9 "
Breadth " "	6 "
Length of coracoid along superior border (about)	4.75 "
Breadth at base	3.5 "
" at point (about)	2.75 "
Length of acromion along inferior border	8.5 "
" " " " superior "	5.5 "
Breadth at point	4.25 "

The superior border is pretty regularly curved, except that towards the last fourth it inclines rather suddenly downward. The external surface is regular and very slightly concave; there is, however, one slight vertical prominence a little in front of its middle, and also a pretty well marked spine running into the acromion, which is thin and bent a little inward at the superior anterior angle. There is a tolerably well marked supraspinous fossa. The anterior edge is sharp; the posterior, particularly near its lower end, thick and rounded. The inner surface has eight slight ridges diverging from the glenoid fossa; the anterior, however, does not reach it. Mr. Murie gives the same number.

The glenoid fossa is irregularly oval and very rough, with projecting edges; it is continued anteriorly into the coracoid process, which is short, solid, and bent inward.

Humerus. — This is a very heavy and solid bone, presenting a broad shaft, a globular head and a tuberosity. On its outer surface the shaft is roughened, except toward the upper and posterior part. A little above the middle there is a considerable depression. The inner aspect presents nothing noteworthy. The posterior side is concave; the anterior is straight. The inferior surface is articular for the radius and ulna. It consists of two parts which meet a little back of the middle in a transverse ridge. The posterior portion, which is for the ulna, does not end on the inferior surface of the humerus, but passes up on to its hinder surface. If the bone be held vertically the globular head (Pl. VI, fig. 11 *a*) projects upward, outward and a little backward. On the inner superior aspect it presents a large depression, from the front of which an ill-defined groove runs downward and outward, corresponding to the "anatomical neck" of human anatomy. From the front of this groove a large and rough tuberosity projects forward and slightly inward. (Pl. VI, fig. 11 *b*.)

MEASUREMENTS.

Length	14.62 in.
Breadth through head and tuberosity	9.25 "
" " about middle of shaft	6.75 "
" " lower end	8.25 "
Thickness through middle of shaft	4.25 "

Radius. — This bone consists of little besides the shaft. Its anterior border is very slightly convex; the posterior rather more than correspondingly concave. The posterior border is thickened at the two ends where it joins the ulna. The anterior border ends above in a small prominence directed forward. On the posterior border there is a large nutrient foramen directed upward.

It should be remarked that the inferior epiphyses which were detached from the radii and ulnæ were very largely cartilaginous, and as only the ossified parts have been retained and replaced, the bones lose something in length.

MEASUREMENTS.

Length	23.37 in.
Breadth at upper end	6. "
" about middle	4.37 "
" lower end	5.87 "
Thickness at about middle	2.25 "

Ulna. — This is a much more delicate bone than the radius. The edges are more curved — the posterior most of all. The anterior edge expands very much in the upper third of the bone. The superior epiphysis forms the articular plate for the inferior surface of the humerus. The olecranon projects backward from about the upper fifth of the bone, and reaches upward so as to fit on to the humerus behind; this part, however, is rough, unlike the rest of the joint. The posterior border of the olecranon is convex; its lower portion very rough. The ulna is expanded at the lower end, where the outer surface is very smooth.

Length (exclusive of olecranon)	22.62 in.
Length of projecting part of olecranon	3 "
Breadth at upper end through olecranon	6.75 "
" " about middle	2.87 "
" " lower end	5.12 "
Thickness at about middle	2 "
Length of olecranon (following curve)	8.75 "
" " " (in straight line)	7.37 "

Manus. — That the number and position of the smaller bones of the flipper might be accurately determined, I placed the undissected left flipper (after it had been separated from the radius and ulna) upon a large sheet of coarse paper, and traced its outline. I then began to remove the skin from one side, and having determined the positions of the bones, traced each of the larger ones upon the paper with slight notes of the peculiarities. The change in the bones by maceration, scraping, etc., has, of course, greatly altered their outlines; but I have been able to identify all the bones of the carpus with great certainty, and though some of the smaller phalanges may have been transposed, yet this (the left) flipper, as now mounted with the bones at the proper distances, may, I think, for all practical purposes be considered absolutely correct. There are six carpal bones, counting one small one on the ulnar side, which is supposed to represent the pisiform bone. The four digits, counting from the radial side, contain respectively five, seven, five and three bones. Before dissection the radial edge of the flipper was thick and rounded, while the ulnar was sharp and thin. The thickest part of the skeleton is through the middle finger (which is much nearer the radial than the ulnar border), and the bones become thinner as they recede from this line, but much more so as they approach the ulnar edge. The bones of the carpus are arranged in two rows; the proximal consists of the radiale, intermedium and ulnare, with the small pisiform beyond. The distal row consists of two; the trapezoid and the unciform (according to the views of Mr. Flower), situated respectively in front of the intervals on either side of the intermedium. Each bone presents two smooth sides which are free; the others being rough for the surrounding cartilage. In the radiale and pisiform alone the two smooth surfaces meet in a rounded border, which lies close to the edge of the limb. The bones of the first row decrease regularly in size from the radial to the ulnar side. The trapezoid is the thickest bone in the carpus, and the unciform the one presenting the greatest extent of surface.

The bones next in order should perhaps be called the metacarpals; but, except in size, they are in no way different from the phalanges. I observed nothing like an epiphysis. The metacarpals of the index and little finger somewhat overlap the carpal bones of the second row. Those of the two intermediate fingers rest upon the trapezoid and unciform respectively. The bases of the metacarpals are thicker than the distal ends. The phalanges of the index differ from all other bones in the hand by a tendency to be slender and cylindrical, while the others are flat and broad.

The flipper of the right side was not dissected with as much care as had been given to the left, which is very much to be regretted, for an additional phalanx was found, and it was not observed whence it came. After studying carefully the appearance of the flipper, and comparing the accounts of the various skeletons in which the number of phalanges has been given, I have decided to place the extra bone on the digit next to the little finger. Thus the formula of the right flipper, beginning at the radial border, will be 5, 7, 6, 3.

It is interesting to notice that all the carpals and almost all the metacarpals and phalanges of the two sides were so like their respective fellows that, with the exception of a very few of the smallest, the position of any bone of the right flipper could be determined by a glance at the left.

Pelvic Bones.

Fig. 11, in text, and Plate VI, fig. 14 (inverted).

One pelvic bone (the left) was removed without being noticed from the body during dissection. When we perceived that the proper place had been passed a long search was made among the pieces of flesh which had been cut off, and the bone at last found. I was so fortunate as to find the bone of the right side in its original position. The rudimentary femur was found on each side. The pelvic bone is thin and triangular. The outer surface is slightly concave; the inner slightly convex. The processes are thicker than the body, particularly the anterior, which is the longest and is flattened below. The inferior border is slightly concave, pretty sharp in the middle, but thick and flat towards the ends. The superior process is broader than the others, but is not much thicker than the body of the bone. The anterior superior border is interrupted by a small notch in the bone of the right side; but that of the left does not show any trace of an indentation.

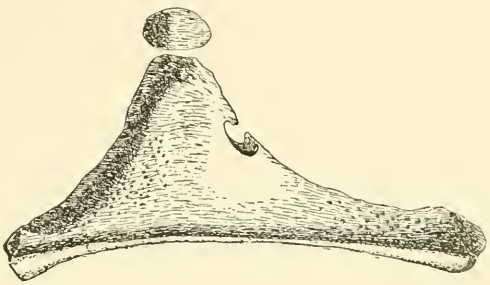


Fig. 11.

The greatest length of the bone of the left side is 8 1-2 inches; of that of the right side 9 inches. The greatest vertical depth is 3 inches on the left and 3 1-2 inches on the right side.

The rudimentary femora were chiefly cartilaginous; but each contained a semi-ossified nucleus. An error in the dissection made their position a matter of some doubt. They were probably situated in front of the position in which they are drawn.

Organ of Hearing.

The auditory apparatus was not studied in the fresh state; the description therefore refers only to the bones. This specimen differs from those of the *B. rostrata* by the firmness with which the petrous and tympanic bones were fixed in the skull. Drs. Carte and Macalister state that the connection was slight, and that the part in question was removed without much difficulty. In this case, on the other hand, the posterior portion was so much overlapped by the squamous and exoccipital bones, that a large piece of the former had to be removed to free it, as well as a scaly plate belonging to the pterygoid, which covered the anterior portion. The right ear was the only one examined. It presents the usual solidity, weighing three pounds, and is divided into the tympanic bulla and into the anterior, posterior and labyrinthic portions of the petrous bone proper.

The *Tympanic Bulla* presents no peculiarities which appear specific; it resembles the drawing of that bone from the *B. rostrata* quite as much as those from the *B. musculus*.

The longest diameter is 5 inches. The external and inferior surface has five convolutions converging upward; the anterior and posterior of these are the continuations of a longitudinal rough ridge about 3-4 of an inch broad, which divides this surface from the upper one, which is smooth and rolled into the cavity of the bone. The anterior external convolution runs upward and backward to the point of union with the anterior portion of the petrous bone. The second and third, though at first separated by a deep fissure, become somewhat fused together; the former is continued into the malleus; the latter into a bold prominence forming the anterior boundary of an opening, which, on the authority of other writers, I consider the meatus externus. The fourth convolution bounds this notch behind, and the fifth terminates on the posterior end of the bone, a little below the point at which the posterior portion joins it.

The anterior and posterior portions unite with the bulla at their respective ends; the labyrinthic, situated at the junction of the two former, is united with the tympanic by the chain of ossicles, which may be appropriately considered now.

The Malleus. — The absence of the membrana tympani at the time of the examination is much to be regretted, as it causes the loss not only of any observations on its position, but also of any on the homologies of the malleus. This bone is coössified with the bulla by a process presenting a deep groove anteriorly, which I am inclined to consider the processus longus. The remainder of the bone consists of two prominences tolerably well separated by a groove; the posterior and larger one is the head; it presents two articular surfaces, which meet at an acute angle; the larger one of these is about vertical, looking backward and inward; the smaller is convex and its general position is horizontal. The anterior prominence represents the manubrium; a small tubercle on its outer side closes the groove dividing it from the head, and may be considered the homologue of the processus brevis. On its inner side is a horizontal ridge, possibly for the insertion of the tensor tympani. Near its base the manubrium is pierced by a minute canal.

The Incus has the general outline of a cone with a bent apex. The bone projects backward and inward. The base is formed by two unequal articular facets, which fit perfectly with those of the hammer. The short process is a mere tubercle on the posterior aspect. The long process is bent upward, and ends in a small oval articulating surface for the stapes, separated from the upper side of the bone by a well marked groove.

The Stapes is placed rather obliquely, the long diameter of the plate running forward and inward; it presents for description a head, two crura and a base. The head has no definite boundaries; there is an oval articular surface on its extremity surrounded by a groove. On the anterior aspect, just before the origin of the crus, there is a rough elevation for the insertion of the stapedius. The posterior crus is the larger and the straighter; the anterior being slightly curved inward. The base is oval to fill the fenestra ovalis, and is broadest near the anterior end. On the outer aspect the crura diverge so as to leave the entrance to a comparatively large passage between them, which is, however, nearly closed by a plate of bone on the inner aspect.

The Petrous Portion. — *The posterior division* is 12 inches long, constricted at its origin, but broad and expanded towards its extremity. It lies in a groove between the squamosal and the exoccipital. Its inferior surface is the only one which presents any points for description. Towards its anterior end it is marked by a deep groove, which at one point is almost made into a canal by a plate projecting from its inner side, and which

runs into the bone at the junction of the anterior and middle divisions. It is the continuation of the aqueductus Fallopii. Beside this one is quite a minute groove apparently for a small vessel or nerve.

The anterior portion is a three-sided pyramid pointing nearly straight forward. The inner side is rough; the others tolerably smooth. There is a considerable prominence near the base on the outer aspect.

The middle or labyrinthic division is the most important, as it contains the vestibule, the cochlea and the semicircular canals. It is conical in shape, the apex being perforated by two foramina of equal size — about one-half inch in diameter — the aqueductus Fallopii anteriorly and the internal auditory meatus posteriorly. In this respect it is very different from that of the *B. rostrata*, as described by Drs. Carte and Macalister. The aqueductus perforates the bone, and changing its course, reappears at the base of the labyrinthic portion and is continuous with the groove in the posterior division. A small canal opens on the anterior aspect of the labyrinthic part. It is found to open into the aqueduct, and is probably for the passage of the chorda tympani. Towards the posterior edge of the upper surface there is a deep funnel-like depression, which, as far as I can ascertain, has no opening at its lower end. Directly internal to this, guarded at its orifice by a bony spine, is the aqueductus cochleæ, which opens into the scala tympani a little inside the fenestra rotunda. I have found nothing to represent the aqueductus vestibuli. The fenestra ovalis is situated in the depths of the cavity of the tympanum, and is surrounded by a raised wall. The fenestra rotunda is, as is usual in Cetacea, considerably removed from the ovalis, being posterior and external to it.

The cochlea was chiselled out by removing with great labor a part of the internal aspect of the bone. It consists of nearly 2 1-3 turns, which is more than I have found described for any whale — the *B. rostrata* having two turns, according to Carte and Macalister, and 2 13-360, according to Hyrtl. With regard to position, the modiolus appears to point very nearly downward when the bone is in place. The scala tympani, as usual in Mammalia, is at first larger than the scala vestibuli, and then smaller. Where the preparation has been slightly broken it is easy to see the spiral canal formed by a cavity in the lamina spiralis described by Hyrtl as peculiar to Cetacea. There is no trace of a lamina spiralis secondaria. The bone was exceedingly brittle and the preparation very difficult, so that the semi-circular canals were quite destroyed — the only description I can offer of them is that they were very minute.

Classification.

From this description there can be no doubt that this is a specimen of the *Physalus antiquorum* of Gray, or the *Balænoptera musculus* of authors and most recently of Van Beneden. The classification of the latter has been chosen as the most "conservative," and the one allowing the greatest scope to individual variation. Whether the Darwinian hypothesis be accepted or not, the opinions of Mr. Darwin on individual differences and on the formation of species and varieties are entitled to the greatest respect, and the following quotations from the second chapter in his "Origin of Species" are very much to the point: "These individual differences generally affect what naturalists consider unimportant parts; but I could show, by a long catalogue of facts, that parts which must be called important,

whether viewed under a physiological or classificatory point of view, sometimes vary in the individuals of the same species. I am convinced that the most experienced naturalist would be surprised at the number of cases of variability, even in important parts of structure which he could collect on good authority, as I have collected during a course of years." "Wide-ranging, much-diffused and common species vary most." "Species of the larger genera" (that is, those having the greater number of species) "in each country vary more frequently than the species of the smaller genera." Now, according to Prof. Van Beneden, all the finners are included in one genus —*Balænoptera*, which is spread throughout the seas, and comprises several species. The *B. musculus* is probably the largest species in point of numbers, and likewise the most widely spread, and *consequently* the one presenting the greatest variations. Distinctions based on the bifurcation of the first rib have been shown by Van Beneden, and subsequently more in detail by Mr. Turner[1] to be of very little value.

It now remains to show how much variation exists by comparing the Boston skeleton and several others one with another. Before dissection the chief peculiarity was the thickness of the body in proportion to its length; this may partly have been due to distention; but the cranium was very uncommonly large, forming a fourth of the length in the flesh, and naturally more in the skeleton. Mr. Flower's drawing in the Proc. Zool. Soc., 1869, represents not only a more slender animal, but one with a more solid and projecting lower jaw. The drawings and measurements of the so-called *P. Duguidii* represent a very narrow body and beak; the flippers are rather longer in proportion. Slight differences in the position of the anterior limb and the dorsal fin are to be found by comparing the measurements of several individuals, but nothing worthy of particular notice.

On comparing the upper aspect of the skull (Pl. VI, fig. 1) with that in Van Beneden and Gervais' "Osteographie," with that in "Recent Memoirs on the Cetacea" by Eschricht, Reinhardt and Lilljeborg (Ray Society, 1866, Pl. III, fig. 3), with that of Eschricht's Nordhval and the Rorqual de la Mediterranée in Cuvier's Ossemens Fossiles, I find that though in several points resembling each, in others it differs from all; it is perhaps most like the last mentioned.

The diversity of the proportions of the breadth of the skull and of the beak to the length of the skull, the latter being taken as one hundred, is very well shown in Mr. Flower's table, Proc. Zool. Soc., 1864, p. 399. In the following table I reproduce his cases of the *P. antiquorum*, adding to them those of the animal taken at Margate, and described by him Proc. Zool. Soc., 1869, three from Lilljeborg's Scandinavian Cetacea and the Boston Whale, calculating the proportions in the same manner, but omitting fractions.

PROPORTION TO LENGTH OF HEAD.

Specimen.	*Breadth of Skull.*	*Breadth of Beak.*	*Specimen.*	*Breadth of Skull.*	*Breadth of Beak.*
Antwerp.	52	18	Margate.	44	17
Louvain.	44	18	Christiania.	45	
Alexandra Park.	46	19	Bergen.	47	
Rosherville Gardens.	45	20	Young (described by Companyo)	37	
(Young) Leyden.	48	21	*Boston.*	46	19
(Young) Mus. R. Coll. Surg.	50	20	Average.	45.81	19.25

[1] Journal of Anatomy and Physiology, vol. v.

This table is, of course, open to objection on the score of perfect accuracy; but it shows clearly that if drawings of all these were placed together, that the diversity of shape would be very striking. In some cases both skull and beak exceed the average breadth; in others both fall short of it, and again, in others sometimes one part, sometimes the other is out of proportion.

The nasals in the Boston whale are very short in proportion to their width, and perhaps are rather smaller than usual. The shape of the supra-occipital is different in all the plates lately referred to; in this specimen, however, it has the narrowness above and the breadth below, which Van Beneden considers a specific character. The supra-orbital plates are remarkable, inasmuch as the inner border is decidedly shorter than usual, thus making the anterior edge less oblique.

The variation in the degree of ossification of the rings of the cervical vertebræ is so generally admitted as to require no comment, unless it be that the non-union in the third is remarkable. The cervical vertebræ are interesting, as in connection with those other specimens they are fatal to the validity of one of the characteristics of the species *P. Duguidii*. The atlas and axis resemble respectively Gray's figures for the *P. Duguidii* rather than those of the *P. antiquorum*. Mr. Murie states that the atlas of the Rosherville Whale approaches that of the former, but the axis that of the latter.

Mr. Heddle, in his paper on the Laman and Copinshay whales,[1] subsequently the *P. Duguidii*, states that in them the transverse processes fall somewhat from the plane of the body, while in the *P. antiquorum* they rise; a little study shows, however, that the difference is usually by no means so great as represented in his diagrams. The fifth cervical of the Rosherville Whale is more like that of the *P. Duguidii*; the same bone in the Boston is more like that of the *P. antiquorum*, but its body is larger in proportion.

The most remarkable point about the vertebral column of this specimen is that it is formed of sixty-three vertebræ, which is one more than has ever been described in this species.

The anterior ribs present a curious variation in being more developed than in the Rosherville whale, although the latter was fully adult.

When the large number of points in which this whale is peculiar is considered, it cannot be denied that bolder feats in classification have been attempted than would be requisite to found a new species on this specimen. Such a course, however, would be quite unjustifiable. It is to be particularly noticed that these variations do not point in any one direction; that if in certain aspects this specimen approaches a certain other, yet in others equally important, it may resemble a third which is quite unlike the second, and in still other respects be different from both. A slight study of the writings of the eminent observers so often quoted will be sufficient to show that the same is true, to a greater or less extent, of perhaps every well described specimen of the species.

In the course of time a greater subdivision will perhaps be warranted, but the best nomenclature is one broad enough to be strengthened and not destroyed by progress.

Before concluding I would express my sense of the kindness of my friend H. G. Curtis, Esq., who made the drawings for all the figures in Plate VI. and all those in the text, except 1 and 2, by Mr. Blake, and 10 and 11.

[1] Proceedings Zoölogical Society, London, 1856, p. 187.

Explanation of Plates.

PLATE VI.

Fig. 1. Superior aspect of skull; *a* and *b* mark certain prominences on the supra-occipital mentioned in the text; *c*, edge of parietal; *d*, frontal; *e*, orbital plate; *f*, vomer; *g*, superior maxilla; *h*, intermaxilla; *i*, nasal.

Fig. 2. Inferior aspect of skull; *a*, exoccipital; *b*, articular portion of squamosal; *c*, periotic; *d*, alisphenoid; *e*, orbital plate; *f*, groove from optic foramen; *g*, vomer; *h*, palatal; *i*, superior maxilla; *j*, intermaxilla; *k*, molar; *l*, lachrymal.

Fig. 3. Anterior aspect of Atlas; *a*, tubercle at origin of transverse process.

Fig. 4. Superior aspect of Atlas; *a*, tubercle at end of articular surface; *b*, true articular surface; *c*, same as in fig. 3.

Fig. 5. Anterior aspect of Axis; *a*, odontoid; *b*, points to tuberosities on diapophyses; *c*, true articular process.

Fig. 6. Posterior aspect of Axis; *a*, zygapophysis.

Fig. 7. Lateral " "

Fig. 8. Last (63d) Vertebra. *Natural size.*

Fig. 9. First rib.

Fig. 10. Anterior surface of Sternum.

Fig. 11. Humerus.

Fig. 12. Radius.

Fig. 13. Ulna.

Fig. 14. Left Pelvic Bone (*drawn inverted*).

PLATE VII.

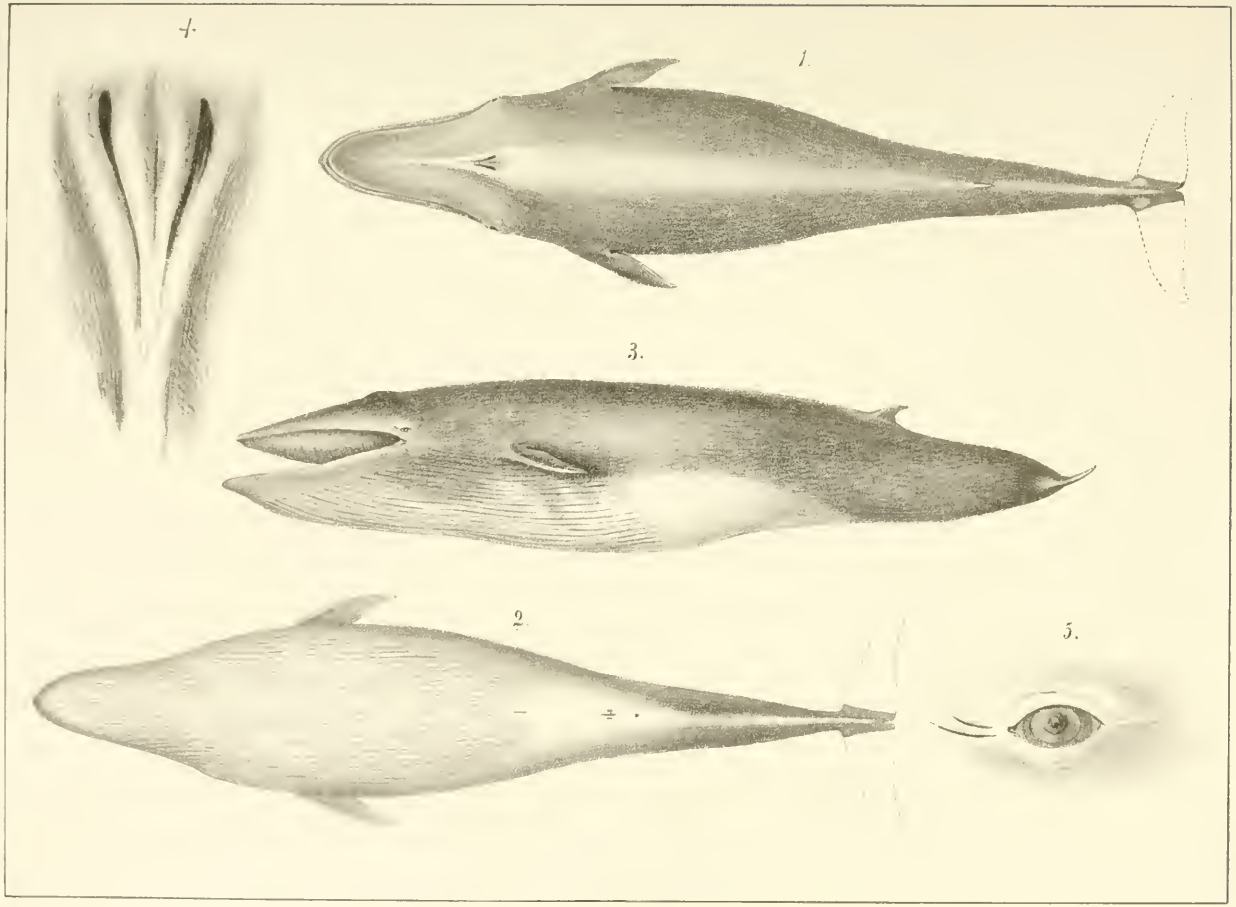
Fig. 1. Dorsal aspect of Whale.

Fig. 2. Ventral " " "

Fig. 3. Lateral " " "

Fig. 4. Blowholes.

Fig. 5. Eye.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VI. On the Carboniferous Myriapods preserved in the Sigillarian Stumps of Nova Scotia. By Samuel H. Scudder.

Among the most curious and interesting results of Dr. J. W. Dawson's researches in the ancient fauna and flora of Nova Scotia is his discovery, in the carboniferous strata at the "Joggins" mine, of erect sigillarian stumps, whose cavities enclosed, with the debris of those ancient times, the relics of a fauna otherwise quite unknown. The land-shells and gally-worms — than which none are known of older date — with fragments of hexapod insects, which had nourished the reptiles of that period and are now preserved in their coprolites, indicate, from their nature and comparative abundance, a fauna of considerable magnitude; three stumps alone, Dr. Dawson informs me, have yielded the articulate remains which I have examined.[1] The gally-worms occur mostly in fragments of from three or four to about sixty segments; but also in smaller bits, enclosed in the masses of reptilian coprolites; hexapod insects scarcely appear except in the coprolites, and although they unquestionably belong to Orthoptera and Neuroptera (of small size), they are in general too fragmentary to justify one in predicating anything of their generic affinities.

In this paper attention is directed to the Myriapoda alone. These were originally referred by Dr. Dawson to a single species and described under the name of *Xylobius sigillariæ*.[2] Greatly to my surprise, I found, on examining them, that they represented not only several species, but two genera of gally-worms. Urged by the doubts both of Dr. Dawson and myself, I subjected the specimens to repeated and most minute inspection, but found my previous opinion confirmed at every step.

The condensed description, originally given by Dr. Dawson, is as follows: —

"Body crustaceous, elongate, articulate, when recent cylindrical or nearly so, rolling spirally. Feet small, numerous; segments thirty or more; anterior segments smooth, posterior, with transverse wrinkles, giving a furrowed appearance. In some specimens traces of a series of lateral pores or stigmata. Labrum? quadrilateral, divided by notches or joints into three portions. Mandibles two-jointed, last joint ovate and pointed. Eyes ten or more on each side." Quart. Journ. Geol. Soc. London, xvi., p. 272.

In stating that the anterior segments were smooth, while the posterior were provided with "transverse wrinkles," Dr. Dawson seems to have drawn his conclusions from a com-

[1] The opportunity of studying them I owe to his kindness.

[2] For previous writings on "*Xylobius sigillariæ*" see:

Dawson, J. W. Quart. Journ. Geol. Soc. Lond., xvi, 268–273, figs. 4–9 (figs. 5, 6, 8, *A. xylobioides*; fig. 9, *X. sigillariæ*); ibid., xviii, 6; ibid., xxii, 116; Air Breathers of the Coal Period, 62–64, 67, pl. vi, figs. 57–61 (figs. 57, 61, *A. xylobioides*; fig. 59, *X. Dawsoni*; fig. 60, *X. sigillariæ*); Can. Nat. and Geol., viii, 280, 283, pl. vi, figs. 57–61 (same as previous); Acad. Geol., Suppl., 33, 34, 36, fig. 45 (*A. xylobioides*); ibid., 2d ed., 385, 386, fig. 151, (fig. 151*b* *A. xylobioides*; fig. 151*c* *X. sigillariæ*).

Woodward, H. Trans. Geol. Soc. Glasg., ii, 235–237, pl. iii, figs. 11–13 (figs. 11, 11*a*, 13, 13*a*, *X. Woodwardi*; fig. 12*a*, *A. xylobioides*).

Scudder, S. H. Dawson's Acad. Geol., 2d ed., 495–496; Geol. Mag., v, 216.

parison of specimens in which the anterior segments only were preserved, with others which he considered posterior segments; but every specimen I have seen either is or is not smooth throughout the whole length of the fragment, and there are quite a number of fragments in which more than half the body is preserved; this distinction is the one upon which I would base my division of these millipedes into two genera. In one (for which the name of *Xylobius* may be retained, since it comprises the larger number both of species and of specimens) the segments composing the body are broken up by longitudinal sutures into little quadrangular plates, of varying form and proportion, which, for want of a better name, I have designated below as *frustra*, and which, to the best of my knowledge, are wanting in any living Myriapoda.[1] In the other, which may be called *Archiulus*, the segments are apparently composed mainly of one unbroken piece, as in recent myriapods. Other distinctions between these groups will doubtless be found; but the imperfect preservation of the fossils — not one of them approaching completeness — forbids their present discovery. In the meantime it does not seem unreasonable to consider this feature alone in the structure of the segments of sufficient importance to separate the groups generically.

Of the genus *Xylobius* four species may be distinguished among the remains from Nova Scotia. For the species best represented both in numbers and in the character of the specimens, I have retained the original name applied by Dr. Dawson.

Xylobius sigillariæ Daws.

There are no large fragments of this myriapod and but few that throw any light upon the form of the terminal portions of the body; the specimens are usually more or less coiled, and the largest, which is 28 mm. in length, is curved in the form of a semi-circle.

[1] Mr. Edward Burgess has called my attention to a myriapod, *Spirostrephon lactarius* (Say) Brandt, which presents a somewhat similar appearance; the segments in this peculiar chilognath bear frequent, longitudinal ridges, very elevated and strongly compressed, the altitude of every other one being double that of the intermediate; the segments are divided by these ridges into quadrilateral sections of much the same proportions as the frustra of *Xylobius sigillariæ* Daws.; but since these sections are perfectly continuous (undivided by any sutures) they can bear no structural affinity or homology with the frustra of *Xylobius*.

Another instance may be seen in *Trachyjulus ceylanicus* Pet. from Ceylon, specimens of which Professor Humbert has kindly given me an opportunity of examining, and which are thus described by him (Essai sur les Myriapodes de Ceylan, pp. 43–46, pl. iii, figs. 18, 18*a*–18*k*); "Each segment is divided into three successive regions; the front one, formed by the articular portion (prozonite), fits into the preceding segment and is regular and smooth; behind it is an annular region marked by numerous projecting longitudinal lines; finally the hinder part of the segment is prominent and furnished with strong longitudinal carinæ, each formed of two sharp spinous tubercles, placed one behind the other and united at their base. These carinæ succeed each other in regular lines from one end of the body to the other, and thus form strong longitudinal ridges which follow those of the first segment. The ridge formed by the median dorsal carina is slightly pronounced; on each side of it are two stronger ones; the second lateral carina projects more strongly than the others, and arises on each side of a strong, black, cylindical tubercle, which is truncated at its summit, where the foramen repugnatorium opens, and followed behind by another smaller sharp tubercle, obliquely docked at the edge; below this series of tubercles, there are five or six other rows, diminishing gradually in size toward the base of the legs." Humbert further states that, in this sculpturing of the segments, *Trachyjulus* greatly resembles *Glyphiulus granulatus* Gerv. from Mauritius.

Markings similar to the sutures dividing the frustra are found in all Iulids in the lines of growth on the lower borders of the sides of the segments; but these invariably become indistinct, and finally invisible at a short distance from the lower border of the segment, and, moreover, never traverse the segment in a straight line, but in a curve across the lower anterior angle, or in lines parallel to such a curve; they are also closely approximate, while the division lines of the frustra are at comparatively wide intervals — altogether too wide to be mistaken for these lines of increment.

The body is cylindrical, of uniform width throughout the principal part and tapering a little at either end; none of the specimens, however, are sufficiently well preserved to ascertain in what degree or over how great an extent the body tapers; one specimen, which shows the posterior three or four segments quite clearly, tapers from 1.95 mm. to 1.5 mm. in breadth in a distance of 1.125 mm.; another fragment occurring in the middle of the body is 18 mm. in length and of uniform breadth throughout. It is of course impossible to determine of how many segments the body was composed, but the largest fragments number twenty-seven and thirty segments, respectively, and the body was probably furnished with at least forty or fifty; the breadth of the body varies from 2.25 mm. to 3.5 mm., and generally averages about 2.75 mm.; at the posterior extremity, however, it measures only 1.15 mm. The segments of the body are a little convex, and measure from .7 mm. to more than 1 mm. in length, averaging .87 mm., the length being to the breadth as 1 to 3.441. The surface is smooth, and both the anterior and posterior borders appear to be slightly incrassated.

The frustra are quadrangular in shape, extend regularly across the segments and are always more than twice, and often more than thrice, as long as broad; in segments which measure from .7 mm. to 1.05 mm. in length, the frustra vary in length from .2125 mm. to .45 mm., and average .29 mm., the breadth being to their length (on an average) as 1 to 3.043; they are so arranged down the sides of the segments that the upper edge of each is always a little higher than the lower edge of the next frustrum above; except in partaking of the convexity of the segment, they are flat.

A single specimen seems to show a slight circular depression in the centre of one of the frustra, which occurs about half way up the sides of the segment; it resembles and is found in the place of the lateral pores.[1] There are two pairs of legs to each segment; they arise in close proximity, and apparently not from the middle of the segment, but from the middle of its anterior half (possibly its posterior half — which, cannot be determined from the imperfect nature of the fragments); they are very long and slender and of nearly equal breadth throughout, tapering at the tip; they vary, probably in different parts of the body, from .6 mm. to 1.45 mm. in length,[2] and the largest are .075 mm. broad: they are apparently composed of five joints; of these the terminal is the longest; the first and second are equal and next in length, and the fourth is the smallest of all.[3]

Xylobius similis sp. nov.

The form of this animal does not seem to differ much from that of *X. sigillariæ* Daws. In one or two specimens, which show some of the terminal segments, the extremities are a little smaller than the middle of the body, the diameter diminishing near the head, in a distance of about 11 mm., from 5.5 mm. to 4 mm.; the hinder end tapers from 3.5 mm., at a distance of 3 mm. from the extremity, to 2.75 mm. at the extremity itself. The number of segments on the fragments vary from twenty-seven to at least forty, and in one specimen apparently to sixty, while in none of them are all the segments preserved.

[1] *Foramina repugnatoria* of Waga.

[2] The length of the legs in this and all subsequent measurements, refers to the distance to which they extend beyond the crushed body.

[3] This statement concerning the joints is doubtful, being based on a single instance, not clearly defined.

The specimens vary in length from 18 mm. to 38 mm., and in breadth 1.5 mm. in minute, probably young, specimens to 5.5 mm. in very large ones; usually they are about 3.5 mm. broad. The segments are a little more convex than in *X. sigillariæ* Daws., and (with one exception, where the segments vary from .165 mm. to .175 mm. in length, and the body is only 1.5 mm. broad) vary in length from .55 mm. to 1.3 mm., where the body ranges from 2.5mm. to 5.5 mm. in breadth; the average length of the segment to its breadth is as 1 : 5.574. The segments are ordinarily smooth, but sometimes appear to be coarsely, irregularly and very faintly scabrous; they are but slightly, if at all, incrassated at the anterior and posterior margins.

The frustra are quadrangular in shape, cross the segments regularly and are generally a little less than twice as long as broad; except in the case of the small specimen already alluded to (where they are .087 mm. in breadth), they vary from .275 mm. to .75 mm. in breadth; in segments, the lengths of which vary from .55 mm. to 1.3 mm. the frustra average .55 mm. in breadth, and the breadth is to the length as 1 : 1.9. As in *X. sigillariæ* Daws., they are flat, except as they partake of the convexity of the segments, and their upper edges are slightly prominent.

Besides the cross lines upon the segments, indicating the division of the frustra, finer, fainter, parallel and more frequent impressed lines are occasionally seen; some which were measured were .0125 mm. broad, and on an average 1 mm. apart. In one specimen I found a whitish substance, which appears to be the altered chitinous coat of the animal, and in this were alternating elevations and depressions crossing the segment, at distances varying from .1 mm. to .175 mm. apart; they are in direct continuation of the fine lines mentioned above, which at this point vary similarly in distance; they differ, however, in that the first mentioned lines are sharply defined furrows, separated by broad plane surfaces, while these are dull grooves between alternating slopes of elevation; in the latter also, the lines of depression are deepened and broadened at regular intervals, giving the whole field a maculate, pitted appearance, apparently found in other chitinous spots, which bear no trace of the lines; it may be noticed that these various sculpturings usually occur on segments near the head and on the lower half of the body.

I have not found any trace of foramina, nor are any legs visible, with the exception, in a single instance, of what seems to be a basal joint; it is .175 mm. broad, or much larger than in *X. sigillariæ* Daws. In one specimen, in exactly the place where the eyes should be, an aggregation of minute tubercles may be seen, arranged in five parallel rows, each row containing from two to five tubercles; very probably these are only accidental roughnesses on the stone.

Xylobius fractus sp. nov.

I have seen but three fragments of this gally-worm, and my knowledge of its structure is correspondingly limited; only one fragment shows what may be an anterior or a posterior end, or both, and it is so imperfectly preserved that one cannot be sure whether the lessening breadth of the extremities is real or accidental. The largest specimen — and this is parted in such a way that it may have belonged to two individuals — is slightly curved in position, 25 mm. long, and composed of forty-five rings, the longer portion counting twenty-eight; another fragment, 7 mm. in length, is composed of sixteen seg-

ments. The body ordinarily varies from 3.5 mm. to 3.75 mm. in breadth, but is sometimes so much distorted as to be only 2.25 mm. broad. The segments are still more convex than in *X. similis* Scudd., exceedingly short, and vary in length from .425 mm. to .675 mm., averaging about .58 mm. only; in other words, the average length of the segments to their breadth is as 1 : 5.617; the surface does not present any noticeable irregularities, and neither the anterior nor posterior margins appear to be thickened.

The frustra are quadrangular in shape, cross the segments regularly and are very nearly square, save at the lower portion of the sides of the body, where they become almost twice as long as broad; they vary in breadth from .275 mm. to .5 mm. averaging .42 mm.; their average breadth is to their length as 1 : 1.353; except in so far as they partake of the convexity of the segments, the frustra are flat, but the upper edge of each is very slightly raised above the surface of the contiguous frustrum. The fine lines which were noticed in *X. similis* Scudd., are also found in this species (probably they are common to all), and occur invariably on the lower half of the body only; in distance apart they vary from .038 mm. to .1 mm., being usually about .075 mm. In one individual, where only one or two segments are preserved, a slight depression, probably a lateral pore, may be seen in the centre of one of the middle frustra of each segment. Only one specimen, and that a very small fragment, preserves any sign of legs; they seem to agree in general with those of the species previously described, but the different joints cannot be distinguished; there are apparently two pairs to each segment; they are 2 mm. in length, and near the base measure from .0625 mm. to .0875 in breadth.

Xylobius Dawsoni sp. nov.

The only representatives of this species before me are two admirably preserved single segments and a crushed mass of contiguous segments, all from the middle of the body; even in the latter case, there are not enough segments to show the form of the body; the parts preserved measure 23.5 mm. in length, are composed of about twenty-five segments, and are of uniform breadth throughout, measuring in this direction 3.5 mm. The segments are quite peculiar, and, if we except their being broken into frustra, resemble very closely those of the single species of the genus *Archiulus*, described further on. The portion of the segment lying, in repose, beneath the adjoining anterior segment (I say anterior by assumption, for the remains themselves do not prove anything), is flat, or nearly so — perhaps slightly concave; while the exposed portion is first (anteriorly) strongly and abruptly convex, making a narrow prominent ridge across the body, and occupying a little more than one-fourth of the length of the exposed portion of the segment, and then regularly and broadly, but rather deeply, concave along the remainder of the segment. The segments are longer than in the other species, varying from 1.15 mm. to 1.65 mm. in length, and averaging 1.5 mm.; but the portion concealed by the overlapping of the contiguous segment, .4 mm. in length, is not given in the measurements of the previously mentioned species, and for comparison with them, must be subtracted; this leaves the average length of the exposed portion 1.1 mm., and the average length of the segment to its breadth as 1 : 3.4. The exposed surface of the segments is provided with a very faint, minute and indistinct punctulation; and also with fine, indistinct lines of sculpture, .25 mm. apart, running parallel to each other and to the anterior and posterior borders of the segment.

The frustra are not regularly quadrangular, as in all the previous species, but the lines of division in crossing the segments curve slightly, and divaricate a little as they pass from the anterior border. If these frustra could slide over each other, as the specimens seem to show, the animal could coil itself more readily and completely than the other species of this genus; the frustra vary in breadth, increasing, in general, in one direction, but whether upwards or downwards, the nature of the remains does not permit us to judge; in the two separate segments they varied thus: first (visible only in one) .35 mm. by .9 mm.;[1] second, .35 mm. to .675 mm., by 1.05 mm. to 1.25 mm.; third, .5 mm. to .875 mm., by 1.1 mm. to 1.25 mm.; fourth, .575 mm. to .7 mm., by 1.25 mm.; fifth, .5mm. to .925 mm., by 1.3 mm. to 1.5 mm.; sixth, .675 mm. to .9 mm., by 1.25 mm. to 1.55 mm.; average .59 mm. to .815 mm., by 1.14 mm. to 1.36 mm., or .7025 mm. by 1.25 mm. Both edges of the exposed portions of the frustra are raised — that which seems to be the upper one to a considerable degree; so that, besides partaking of the varying contour of the segment, the frustra are slightly and oppositely concave; the lines dividing the frustra run through the concealed, as well as through the exposed portion of the segment, but, in the former case, they do not have their edges raised, and the lines of separation are straight, less distinct, and run at right angles to the anterior border of the segments. The concealed portion of the segment is also provided with fine impressed lines crossing it at right angles to the anterior border of the segment; they are placed at an average distance of .075 mm. apart, but every other one is more deeply impressed and conspicuous. Although some of the specimens are remarkably preserved, I have been unable to detect any trace of lateral pores, and no legs can be seen on any of the fragments. The well preserved single segments are probably from the region near the head where lateral pores do not occur.

The genus *Archiulus* has but a single representative among these sigillarian relics; in general appearance it resembles the last mentioned species, and may be called

Archiulus xylobioides gen. et sp. nov.

As this species includes some of the best preserved and most completely coiled specimens among the fossils, nearly every part of the body can be seen in a more or less perfect manner. Excepting at the two ends, the body must have been of nearly uniform width throughout; at about the seventh segment it begins to taper anteriorly, at first gradually, afterwards quite rapidly, so that the segments adjoining the head are scarcely more than half the width of those in the middle of the body; the head itself appears to be well rounded, and to have no ridge or crest; apparently the body tapers neither so rapidly nor considerably at the posterior end, although the fragments of this part are less perfectly preserved. None of the fossils exhibit all the segments of the body, but vary in length from 7 mm. to 26.5 mm., and in the number of segments from nine to thirty-three; probably full grown individuals had as many as forty or forty-five segments. The middle of the body varies from 2.5 mm. to 4.5 mm. in breadth, averaging 3.1 mm.; in one instance, at a distance of 15 mm. from the head,

[1] The shorter measurement is the breadth of the frustrum, the longer its length; when two sets of measurements are given, the first in every case refers to the same specimens.

it measured 4.25 mm., and at a distance of 7.5 mm., 3.25 mm.; at 5 mm. from the head it measured 2.5 mm. (the average breadth at this point is 2.375 mm.), and next the head 1.62 mm.. One specimen, closely coiled, the body of which at its widest part was 2.75 mm. in breadth, measured 4.625 mm. across the coil. Beneath, there is a faintly impressed line along the middle of the body, on either side of which the lines of divisions of the segments are inclined a little posteriorly. The segments are shaped much as in *X. Dawsoni* Scudd., but are not broken up into frustra; the anterior ridge is more prominent, and occupies a greater extent of each segment in the anterior part of the body, and especially in the first seven segments, than in the posterior part; and when the body is coiled, the hinder edges of the segments project strongly above the adjoining ring, much as it is represented in some of Dr. Dawson's illustrations; other fragments show that the lower edges of the segments were well rounded posteriorly; the segments are proportionally a little longer close to the head than in the middle of the body; in general they vary in length from .8 mm. to 1.5 mm., averaging 1.28 mm. (but one segment, near the head, in a small specimen, measured only .475 mm.), while the breadth varies from 1.62 mm. to 4.5 mm.; the average length of the segment to the breadth is as 1 : 3.05; the ridge occupies from one-fifth (in the middle of the body) to nearly nine-twentieths (near the head) of the entire length of the segment. In some specimens, which seem to be a little worn, the surface is perfectly smooth, but in others the altered integument is apparently marked with broad, shallow, circular, tessellated pittings, the centres of which are .0875 mm. apart; there are fine, parallel, longitudinal lines on the segments, varying from .04 mm. to .2 mm. apart; those on the under surface, or on the lower portion of the sides of the segments, seem to be in closest proximity, but the lines on the upper surface are sometimes not more than .875 mm. apart.

The foramina repugnatoria are more distinctly preserved in some specimens of this species than in any of the other fragments of fossil myriapods which I have examined; they occur from the seventh segment backward (I could not determine how far, but at least to the seventeenth segment), and are placed in the middle of the sides of the segments; they are oblong oval in shape, with their longer diameters vertical; the mean of their diameters averages .2 mm.. A specimen of the under surface seems to show that the legs are inserted close together, one a little outside the other; together they are placed in the middle of the anterior half of the segment, and about midway between the ventral line and the outer edge; they vary in length according to their position on the body; on the fifth segment, where they commence, they are from 1.35 mm. to 1.8 mm. long, while at the middle of the body they measure from 1.75 mm. to 2 mm. long; at the base they average less than .1 mm. broad.

I cannot determine whether the animal had any eyes, but the tubercles delineated by Dr. Dawson cannot be considered as such, for an examination of his original specimen shows, as his illustration itself indicates, that these tubercles are placed in the segment behind that which should bear the eyes; and, moreover, similar tubercles may be seen on other segments, and indeed on other parts of the stone where there are no organic remains; in another spot, close to the base of the antennæ, and exactly where Newport represents the eye of the immature Iulus, two or three minute tubercles, .0167 mm. in diameter, are situated close together at the upper edge of an abrupt pit in the stone, which — if these are parts of the eye — has engulfed the rest; these are the only possible indica-

tions of eyes which I have been able to find. There are, however, two fragments of antennæ; one is broken and parted, and simply indicates that the original was probably at least .9 mm. long, and in one place .2 mm. broad; the other is comparatively well preserved, and shows that the fossil myriapod preserved in its maturity the simple form of antenna, now characteristic of adolescence; it seems to be 1.3 mm. long, and is composed of four joints, forming two parts somewhat similar in appearance; the first and second joints together have an oblong oval, well rounded outline, and run in a nearly straight direction; while the third and fourth have a somewhat similar outline, but are a little curved, lunate or reniform; that is, the first and second are connate (or at least in no degree moniliform), as are also the third and fourth, while a deep constriction nearly divides the second and third; the exact shape of the first cannot be determined, but it appears to be a little larger at the apex than at the base, and about as long as its extreme width;[1] the second is docked squarely at the base, and is of equal width for a short distance, when it tapers gradually to a well rounded apex, where it unites with the third; it is .4 mm. long, .3 mm. broad at the base, and .1625 mm. broad at the tip; the third, which forms almost the whole of the outer half of the antenna mentioned above, is .6 mm. long, and .375 mm. in extreme breadth; it is broadest in the middle, and tapers toward either end, being .15 mm. broad, where the minute apical joint is connate with it; the fourth, or apical joint, is but .1 mm. in length, only serving to round off the tip of the antenna; were it not for the deep constriction at the middle of the antenna, this organ would closely resemble the representations of the young Iulus given by Newport; the surface of the whole antenna seems to be marked with very minute, irregular, raised points, not crowded together.

I ought here to speak of the remains referred doubtfully by Dawson to a labrum; they are situated next to the head, but are equal to it in size, and seem to be three or four connected segments of the abdomen of some orthopterous or neuropterous insect; their whole length is 2.15 mm., and they vary from 1.1 mm. to 1.45 mm. in breadth.

Mr. Henry Woodward, of the British Museum, in an article printed in the Transactions of the Geological Society of Glasgow,[2] has announced the first discovery in Great Britain of a species of *Xylobius;* having examined specimens from Kilmaurs, Ayrshire, and from Cooper's Bridge, near Huddersfield, he states that he does not "think the specimens of this fossil entitle us to consider it as specifically distinct from that discovered by Dr. Dawson, although a comparison of the figures may convey that impression." The illustrations of the English specimens given by Mr. Woodward differ so greatly from each other, that one would almost feel justified in believing they belonged to two distinct species; I would hardly hazard such an opinion without a comparison of the specimens themselves, yet I cannot believe that they belonged to any species I have had before me, unless the illustrations greatly misrepresent the comparative length and breadth of the segments; in these drawings the segments are half as long as broad; in the Acadian species they vary from a proportion of 1 to 3.05 to that of 1 to 5.574. I am convinced, both from this and from similar differences, that the British species — if there be only one — must be distinct from any of the American ones, and I therefore propose for it the name of *Xylobius Woodwardi.* That the English specimens belong to *Xylobius,* and not to *Archiulus,* is probable, for

[1] There may be more than one joint at this place, although one only can be seen.

[2] Vol. II, pt. iii, pp. 231–248.

Mr. Woodward states that "the segments are marked by alternate ridges and furrows, and the surface presents a somewhat rugose appearance, very different from the smooth and shining articuli of the recent Iulus," and again, "this shows the segments to have been ornamented with transverse, finely undulating lines." If the cross lines given in one of Mr. Woodward's figures are correctly rendered, and represent the frustra into which the segment is broken, we have an additional feature distinguishing the species, for these frustra are far longer and narrower than those of *X. sigillariæ* Daws., the most extreme of the American species in this particular; the engraver has of course rendered the legs inaccurately in making the tips furcate, since in all myriapods they are furnished with only a simple claw; the length of the legs is another point of distinction, if we are to judge from the plate, but as the description of these parts is so greatly at variance with the figures,[1] we will only draw attention to the necessity of examining this point more carefully. The British specimens seem to be much more perfect than any I have seen.

It seems fairly deducible from the above detailed descriptions, that these fossil myriapods compose a family of chilognaths, closely allied to the Iulidæ, but distinct from any now living, and to which the name of *Archiulidæ* may be applied. They may be characterized as having a cylindrical (or subcylindrical?) body of uniform size throughout the principal portion, but tapering, at either extremity, to about half the dimensions of the central portions of the body; they are composed of a large number of segments, not differing greatly in character from those of Iulidæ, and furnished with lateral pores of a large size from the seventh segment posteriorly; the legs are attached in double pairs to the anterior half of each segment posterior to the fourth, and are not known to be present on segments anterior to these; the head is destitute of eyes, or, if furnished with them, the ocellar tubercles are few in number, and rather distant from each other; the antennæ are composed of four (?) joints, very simple in structure. The genus *Xylobius* may be defined as an Archiulid, in which the segments — with the exception of those composing the head and anal plates — are broken by sutures into fragments which may be termed frustra, which run anteriorly and posteriorly across the segment; the segments themselves are either slightly and regularly convex, or ridged anteriorly. The genus *Archiulus* closely resembles *Xylobius*, but the segments are not broken into frustra, and, in the single species known, are prominently ridged on the anterior borders of the segment; the antennæ are divided into two nearly equal halves by a deep constriction between the second and third joints.

[1] The figure represents the legs as nearly twice as long as the width of the body, but the author states that the body is "two lines across the widest, and one line across the narrowest segment," and that the legs are "one line in length."

VII. Note additionnelle *au Mémoire de M. W.-T. Brigham, intitulé*: "Volcanic Manifestations in New England (1638–1870)." Par M. Albert Lancaster, attaché au Secrétariat de l'Académie royale des sciences de Belgique.

La Société d'histoire naturelle de Boston a publié, dans le volume II de ses Mémoires, un travail de M. William T. Brigham, sur les tremblements de terre et autres phénomènes séismiques observés dans la Nouvelle-Angleterre depuis 1638 jusqu'en 1870.

Pour ce qui concerne les manifestations volcaniques enregistrées dans les siècles antérieurs au nôtre, le mémoire de M. Brigham renferme, je pense, tout ce que l'on pouvait espérer recueillir; il mentionne même quelques faits qui avaient échappé à notre savant ami, M. Alexis Perrey, lorsque celui-ci fit paraître, en 1850, son Mémoire sur les tremblements de terre aux États-Unis et dans le Canada.

Par contre, certaines lacunes, — en petit nombre il est vrai — existent, dans le travail de M. Brigham, quant aux notes relatives au siècle actuel. Elles concernent principalement la période de 1840 à 1870, la plus récente par conséquent, mais aussi celle sur laquelle les renseignements sont le plus nombreux.

Grâce aux relevés séismiques annuels que publie M. A. Perrey depuis plus d'un quart de siècle,[1] et aux recherches que j'ai faites dans plusieurs recueils scientifiques des États-Unis,[2] je crois être à même de combler ici,— en partie du moins,— ces lacunes, et d'ajouter, par ce fait, quelques documents de plus aux matériaux déjà nombreux réunis par M. Brigham.

J'ose espérer que la note suivante sera de quelque utilité, aujourd'hui surtout que l'étude de la séismologie prend chaque jour plus de développements et mérite toute notre attention par les résultats intéressants et curieux qu'on peut en attendre.

1728. *Juin.* Le 4 (nouveau style), vers 11 h. du soir, à Newbury, tremblement accompagné d'un bruit fort et long.

Septembre. Dans le courant du mois, à Newbury et à Rowley, secousse de tremblement de terre accompagnée d'un bruit semblable au tonnerre.

[1] Les relevés pour les années de 1843 à 1852 ont paru dans les Mémoires de l'Académie de Dijon; ceux de 1853 à 1855 dans les Bulletins de l'Académie de Belgique, et de 1856 à 1869 dans les Mémoires in-8° de la même Académie.

[2] Je citerai principalement les Reports des Régents de l'Université de New-York, les Monthly Reports du Département de l'Agriculture à Washington et l'American Journal. J'ai puisé aussi plusieurs renseignements dans le recueil que publie M. Plieninger, sous le titre de, Jahresbericht über die Witterungs-Verhältnisse in Württemberg.

1732. *Décembre.* Pendant la dernière quinzaine du mois (n. st.), plusieurs secousses à Newbury.

1819. *Août.* Le 15, au village de St. Andrew (Bas-Canada), secousse accompagnée d'une forte explosion.

1838. *Décembre.* Le 23, vers 4 h. du soir, à Woodhouse (Canada), secousse précédée d'un bruit souterrain.

1843. *Mars.* Le 14, secousses sur divers points de l'État de Vermont.

Novembre. Le 10, tremblement de terre au Canada.

1844. (*Sans date mensuelle.*) A Montréal (Canada), tremblement signalé sans détails par M. J.-W. Dawson, dans son mémoire sur le tremblement du 17 octobre 1860.

1845. *Novembre.* Dans le courant du mois, une secousse à Lebanon (N.-H.). Elle a occasionné le glissement d'une portion considérable de collines avec les maisons et les arbres qui étaient dessus, mais sans changer leur position relative.

1846. *Août.* Le 25, à 5 h. du matin, tremblement de terre aux États-Unis. On l'a ressenti près de Portland (Maine), dans le Massachusetts et dans le New-Hampshire. A Boston, la secousse s'étendit à 20 lieues dans les environs et fut accompagnée d'un bruit semblable à un tonnerre lointain.

Novembre. Le 12, à 7 h. 40 m. du soir, secousse à Deerfield (N.-H.).

1847. *Janvier.* Le 14, à Rice-Lake (Canada oriental), tremblement accompagné de la rupture de la glace, dont les fragments s'amoncelèrent les uns sur les autres.

Dans le courant du mois, tremblement à Bangor (Maine).

(*Sans date mensuelle.*) A Montréal (Canada), tremblement signalé sans détails par M. Dawson.

1848. Le tremblement de terre signalé par M. Brigham à la date du 9 septembre, est renseigné, dans le 62e Annual Report of the Regents of the University of New York, comme ayant eu lieu le 8 septembre. Pour le reste, les détails sont absolument les mêmes.

1851. *Octobre.* Le 11, à 9 h. 30 m. du soir, tremblement à Deerfield (New-Hampshire); atmosphère parfaitement calme, température: 75° F.; pluie le lendemain.

Décembre. Le 25, quelques minutes avant 8 h. du matin, à Bridport (Vermont), secousse de quelques secondes.

1852. *Décembre.* Le 15, à 4 h. du soir, à Carlton (comté d'Orleans, New-York), une secousse.

1853. *Mars.* Le 13, 5 h. du matin, à Ste. Catherine, Niagara, secousse.

Le même jour, à la même heure, à Grimsby, Jordan, Thorold, Fells, Queenston, Fort Mississangua et dans tout le Canada, quatre secousses.

Juin. Le 17 et le 20, à Portland (Maine), deux tremblements.

Juillet. Le 20, dans l'après-midi, à Portland (Maine), tremblement.

Août. Le 17, à New-Bedford (Massachusetts), tremblement.

Novembre. Le 21, à Antrim (N.-H.), violent tremblement.

Novembre. Le 28, à Antrim encore, nouveau tremblement de terre violent.

1854. *Janvier.* Le 24, 7 h. du matin, et le 27, à la même heure, à Palmer (partie occidentale du Massachusetts), deux secousses, avec bruit sourd (*loud noise*) très distinct.

Octobre. La secousse mentionnée par M. Brigham comme ayant eu lieu pendant ce mois à Keene (New-Hampshire), a été ressentie le 24, à 10 h. du soir. Elle fit osciller sensiblement les maisons.

Janvier. Le 13, 5 h. 40 m. du matin, à St. Martin (île Jésus, Bas-Canada), 9 milles à l'O. de Montréal, légère secousse. 1855.

Janvier. Le 16, vers 6 h. du soir, à Hanover, White Mountains, Walpole, Portsmouth (New-Hampshire), Bradford, Newburyport, St. Johnsbury (Vermont), Bridgeton, Portland, Bethel, Hiram et le long de Long Pond (Maine), violente secousse. On indique aussi 7 h. 20 m. pour les localités du Maine.

Janvier. Le 17, à Mount Vernon et à Freeport, secousse.

Janvier. Le 19, 11 h. du matin et 8 h. 30 m. du soir, à Portland (Maine), secousse.

Janvier. Le 23, 3 h. du soir, à Newburyport (Massachusetts), tremblement.

Février. Le 4, dans le Maine et le Nouveau-Brunswick, une forte secousse.

Février. Le 6, un peu avant minuit, dans les États de New-York et de Massachusetts, deux secousses accompagnées d'un bruit fort. A Kinderhook et à Stuyvesant Falls le sol s'est fendu en plusieurs endroits sur une largeur de deux à trois pouces. A Saugerties, (comté d'Ulster, N.-Y.), et à Springfield (Massachusetts), on a entendu de fortes explosions.

Février. Le 8 eut lieu un tremblement sur lequel M. Brigham a déjà donné quelques détails; en voici de nouveaux:

Février. Le 8, 5 h. 30 m. du matin, à Eastport, Bangor et Waterville (Maine), une secousse; 6 h. 45 m. du matin, à St. John's (N.-B.), Fredericton, Halifax, Dartmouth, Windsor, Chatham, Sussex-Vale, Bathurst, Miramichi, Truro, Pictou et dans d'autres localités du Nouveau-Brunswick et de la Nouvelle-Ecosse, une secousse qui paraît s'être étendue jusqu'à l'île de Prince Edward, et qui a été accompagnée d'un bruit plus ou moins violent, suivant les localités.

Elle a brisé des fenêtres. Une personne qui se trouvait près d'une rivière gelée dit que les ondulations, très-fortes, imprimèrent leurs mouvements à la glace.

Avril. Le 18, mouvement extraordinaire des eaux au lac Ontario. Le même phénomène se présenta aux lacs Seneca, Huron, Cayuga et Skaneateles.

Mai. Le 29, 5 h. du matin, à Coos (New-Hampshire), violente secousse avec détonation semblable au tonnerre.

Juin. Sous le titre de: Volcanic phenomena in Nova Scotia, on lit dans The New York Tribune, du 21: "Un correspondant de The St. Johns News dit que la population des environs de Digby (Nouvelle-Ecosse) est dans une grande émotion à cause des commotions terrestres qui ont eu lieu dans le S. E. des Granville Mountains. Le jour du tremblement de terre qui a eu lieu il y a quelques mois, la montagne, fortement ébranlée, s'est ouverte et a lancé beaucoup de fumée le reste du jour. Tout était resté calme jusqu'au nouveau tremblement qui s'est fait sentir il y a une quinzaine de jours; il s'est formé un nouveau gouffre dans la montagne et les secousses ont continué ensuite; la montagne a lancé de la fumée, de la poussière et des pierres. Le phénomène continue encore, sans que personne ose en approcher."

Décembre. Le 17, vers 2 h. du soir, à French Mountain, (comté de Warren, N.-Y.) et aux environs, forte secousse; dans un puits, à 30 pieds de profondeur, des ouvriers l'ont vivement ressentie. Dix ou quinze minutes plus tard, nouvelle secousse légère.

1856. *Mars.* Le 12, vers 10 h. du soir, à Madison (Connecticut), et dans les villes voisines, secousse d'environ 30 secondes de durée, suivie d'un bruit semblable à un tonnerre lointain. Beau temps ; pas de dégâts.

Juin. Le 4, pendant un orage, l'eau du lac Ontario s'est élevée soudainement de trois pieds, pour baisser presque aussitôt. Le même mouvement s'est produit à plusieurs reprises, en causant quelques avaries aux navires qui se trouvaient sur le lac.

1857. *Juin.* Le 30, à 10 h. 45 m. du soir, tremblement de terre dans le Connecticut.

Octobre. Le tremblement signalé par M. Brigham à la date du 8 octobre 1858, doit être reporté au 23 octobre 1857. L'American Journal, que M. Brigham cite en note, indique, sans qu'il y ait à s'y méprendre, que le phénomène a eu lieu à la seconde de ces deux dates et non à la première (Volume XXVI, pp. 177–182).

Décembre. Le 28, dans le Maine, tremblement de terre.

1858. *Juin.* Le 27, à New-Haven, tremblement léger.

1861. *Mars.* Le vendredi (1 ou 8 ?), dans le Massachusetts, deux secousses mentionnées sans date précise dans le New York Weekly Herald, du samedi 9 mars : " Le Bunker Hill Aurora dit que deux secousses de tremblement de terre ont été observées dans cette ville (Charlestown, Mass.), vendredi, peu de temps avant le tonnerre et les éclairs." Dans le même numéro de ce journal on lit aussi : " Le Newark (N.-J.) Mercury dit que deux secousses distinctes ont été ressenties dans cette ville, mardi vers midi. A Orange les portes ont été secouées ainsi qu'à Patterson, à Belleville et dans d'autres localités voisines. Bloomfield les cloches ont sonné."

Les dernières secousses sont évidemment du mardi, 5 mars.

Octobre. Dans le courant du mois, une légère secousse à l'île Jésus (Canada oriental) Extrait du Canadian Naturalist and Geologist, tome VII, page 43.

1868. *Mars.* Le 1er, à Augusta (Maine), légères secousses de quelques secondes de durée.

1869. *Avril.* Le 9, entre 8 et 9 h. du matin, à Vienna (Ontario), une légère secousse du N. au S. et de vingt secondes de durée.

Décembre. Tout à la fin du mois, une secousse violente à St. Paul Bay, 40 milles au-dessous de Québec (Canada). Extrait du Richmond Enquirer du 1er Janvier 1870.

1870. *Février.* Le 8, à Richmond et dans le voisinage, sur la côte du Maine, une secousse.

Octobre. Le 23, 6 h. 30 m. du matin, à Springfield, une secousse légère.

En tenant compte des faits consignés dans la note qui précède et des nombreux renseignements que nous fournit le mémoire de M. Brigham, nous arrivons à former le tableau suivant, par années et par mois, des tremblements de terre ressentis dans la Nouvelle-Angleterre, de 1638 à 1870.

Années.[1]	Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août	Septembre	Octobre	Novembre	Décembre	Sans date mens'le	Total
1638	.	.	.	.	.	1	.	.	.	.	.	.	.	1
1642	.	.	1	.	.	1	.	.	.	.	.	.	.	2
1653	.	.	.	.	.	.	.	.	.	.	1	.	.	1
1658	.	.	.	1	.	.	.	.	.	.	.	.	.	1
1660	.	1	.	.	.	.	.	.	.	.	.	.	.	1
1662	.	1	.	.	.	.	.	.	.	.	1	.	.	2
1663	.	2	.	.	.	.	.	.	.	.	.	.	.	2
1665	.	.	1	.	.	.	.	.	.	1	.	.	.	2
1668	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1669	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1670	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1706	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1720	1	.	.	.	.	.	.	.	.	.	.	.	.	1
1727	.	.	.	.	.	.	.	.	.	.	10	2	.	12
1728	2	5	4	.	3	5	1	1	1	.	.	.	.	22
1729	.	1	1	.	.	.	.	.	1	1	2	1	.	7
1730	.	1	1	1	.	.	.	2	.	.	2	4	.	11
1731	2	.	1	.	.	1	1	.	1	1	.	.	.	7
1732	.	1	.	.	.	.	.	.	1	.	.	1	.	3
1733	.	.	1	.	.	.	.	.	.	1	.	.	.	2
1734	1	.	.	.	.	.	1	.	.	1	2	.	.	5
1736	.	1	.	1	.	.	1	.	.	1	1	.	.	5
1737	.	1	.	.	.	.	.	.	1	.	.	1	.	3
1739	.	.	.	.	.	.	.	1	.	.	.	1	.	2
1740	1	.	1	.	.	.	.	.	.	.	.	.	.	2
1741	.	.	.	.	.	1	.	.	.	.	.	1	.	2
1744	.	.	.	.	1	1	.	.	.	.	.	1	.	3
1746	.	1	.	.	.	.	.	.	.	.	.	.	.	1
1755	.	.	.	.	.	.	.	.	.	.	2	1	.	3
1756	1	.	.	.	.	.	.	.	.	.	1	1	.	3
1757	.	.	.	.	.	.	1	.	.	.	.	.	.	1
1758	.	.	.	1	.	.	.	.	.	.	.	.	.	1
1759	.	1	.	.	.	.	.	.	.	.	.	.	.	1
1760	.	1	.	.	.	.	.	.	.	.	1	.	.	2
1761	.	1	2	.	.	.	.	.	.	.	1	.	.	4
1766	.	1	.	.	.	1	.	1	.	.	.	1	.	4
1783	.	.	.	.	.	.	.	.	.	.	1	.	.	1
1785	1	.	.	.	.	.	.	.	.	.	.	.	.	1
1786	.	.	.	.	.	.	.	.	.	.	1	.	.	1
1787	.	1	.	.	.	.	.	.	.	.	.	.	.	1
1791	.	.	.	.	3	.	.	.	.	.	.	1	.	4
1792	.	.	.	.	.	.	.	1	.	1	.	.	.	2
1793	1	.	.	.	.	.	1	.	.	.	.	.	.	2
1794	.	.	1	.	.	.	.	.	.	.	.	.	.	1
1800	.	.	.	.	.	.	.	.	.	.	1	1	.	2
1801	.	.	1	.	.	.	.	.	.	.	.	.	.	1
1805	.	.	.	.	.	.	.	1	.	.	.	1	.	2
1810	.	.	.	.	.	.	.	.	.	.	1	.	.	1
1812	.	1	.	.	.	.	1	.	.	.	.	.	.	2
1813	.	.	.	.	.	.	.	.	.	.	.	1	.	1
1816	.	.	.	.	.	.	.	.	2	.	.	.	.	2
1817	.	.	.	.	.	.	.	.	.	1	.	.	.	1
1818	.	.	.	.	.	.	.	.	.	1	.	.	.	1
1819	.	.	.	.	.	.	.	1	.	.	1	.	.	2
1821	.	1	.	.	.	.	.	.	.	.	.	.	.	1
1824	.	.	.	.	.	.	1	.	.	.	.	.	.	1
1827	.	.	.	.	.	.	.	1	.	.	.	.	.	1
1828	.	.	.	.	.	.	.	1	.	.	.	.	.	1
1829	1	.	.	.	.	.	.	.	.	.	.	.	.	1
1831	.	.	.	.	.	.	1	.	.	.	.	.	.	1

[1] Toutes les dates du tableau récapitulatif de M. Brigham écrites dans le vieux style, ont été ramenées au nouveau style dans le présent tableau.

Années	Janvier	Février	Mars	Avril	Mai	Juin	Juillet	Août	Septembre	Octobre	Novembre	Décembre	Sans date mens'le	Total
1832	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1833	.	.	1	1	.	.	.	.	.	.	.	.	.	2
1837	.	.	.	1	.	.	.	.	.	.	.	.	.	1
1838	.	.	.	.	.	.	.	.	.	.	.	1	.	1
1840	.	.	.	.	.	.	.	1	1	.	.	.	.	2
1842	.	.	.	.	.	.	.	.	.	.	1	.	.	1
1843	.	.	1	.	.	.	.	.	.	.	1	.	.	2
1844	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1845	.	.	.	.	.	.	.	.	.	1	1	.	.	2
1846	.	.	.	.	1	.	1	1	1	2	1	1	.	8
1847	4	4	.	1	.	1	1	1	.	.	.	.	1	13
1848	1	1	.	.	1	.	.	.	1	.	1	1	.	6
1849	.	2	.	.	.	.	.	.	.	1	.	.	.	3
1850	.	.	.	.	.	.	1	.	.	.	.	.	.	1
1851	2	.	.	.	.	.	.	.	.	1	.	1	.	4
1852	1	1	.	1	.	3	.	3	.	.	1	1	.	9
1853	.	.	2	.	1	.	2	1	1	.	2	.	.	12
1854	1	1	.	.	.	.	.	.	.	1	.	2	.	5
1855	5	4	.	.	1	.	.	.	.	.	.	1	.	11
1856	.	.	1	.	1	1	.	.	.	.	.	1	.	3
1857	.	.	.	.	.	1	.	.	.	2	.	1	.	4
1858	.	.	.	.	2	2	.	.	.	1	.	.	.	5
1859	.	.	.	.	.	.	.	.	.	.	.	.	1	1
1860	.	.	1	.	.	.	.	.	.	1	.	.	.	2
1861	.	.	2	.	.	.	1	.	.	.	.	.	.	3
1862	.	2	.	.	.	.	.	.	.	.	.	.	.	2
1864	.	.	.	1	.	.	.	.	.	1	.	.	.	2
1867	.	.	.		.	.	.	.	.	.	.	1	.	1
1868	.	.	1	.	.	.	.			.	.	.	.	1
1869	.	.	.	1	.	.	.			1	.	1	.	3
1870	.	1	.	.	.	.	.	.	.	2	.	.	.	3
Total général	25	38	24	10	14	19	15	17	11	23	37	31	8	272

Il n'entre pas dans nos intentions de présenter ici la discussiou des résultats que fournit le tableau ci-dessus: MM. Perrey et Brigham, dans leurs importants mémoires sur les tremblements de terre aux États-Unis, se sont déjà chargés, en partie, de ce soin, et je ne pourrais que répéter ce qui a été dit par ces savants distingués. Je me bornerai à signaler quelques conséquences assez curieuses que l'on peut déduire des faits consignés dans notre tableau, conséquences qui méritent, je pense, qu'on s'y arrête un instant.

Notre examen portera d'abord sur la fréquence annuelle du phénomène.

Si nous envisageons la période de 1638 à 1870, pendant laquelle on compte 272 jours de tremblements de terre, nous trouvons le rapport 1.2 seulement comme nombre de manifestations séismiques qui se présentent chaque année dans la Nouvelle-Angleterre. Mais ce chiffre est évidemment trop faible, les données concernant les 17e et 18e siècles étant, à n'en pas douter, fort incomplètes. Nous préférons donc présenter le rapport annuel pour chaque siècle, ce qui offrira plus de certitude. De la sorte, on a:

17e siècle . . . . . 0.2 trembl.
18e " . . . . . 1.2 "
19e " . . . . . 2.0 "

Il est à supposer que ce dernier chiffre 2.0, fourni par les documents concernant le 19e siècle, est celui qui se rapproche le plus de la moyenne exacte; on peut donc en conclure que *deux tremblements de terre ont lieu, annuellement, dans la Nouvelle-Angleterre.*

Si nous examinons maintenant les nombres du tableau précédent au point de vue du

total par mois, nous remarquons aussitôt qu'il existe deux *maxima* et deux *minima* très-prononcés, égaux deux à deux à une unité près ; les uns tombent en *février* et *novembre*, les autres en *avril* et *septembre* ; ils sont entre eux comme 3.6 : 1.

En faisant la répartition d'après les mois d'hiver et ceux d'été, nous obtenons :

Mois d'hiver (oct., nov., déc., janv., fév., mars)	178
Mois d'été (avril, mai, juin, juill., août, sept.)	86
Sans indication de mois	8

Nous sommes ici en présence d'un résultat très-remarquable, c'est-à-dire la prépondérance considérable de l'hiver sur l'été : les nombres sont comme 2.1 : 1.[1] D'après l'inspection de l'ensemble des documents publiés par M. Perrey sur les tremblements de terre, ce rapport serait le plus élevé de tous ceux que l'on a reconnus jusqu'à ce jour pour n'importe quelle région physique ; si nous lui comparons celui obtenu pour le Pérou, la Colombie et le bassin de l'Amazone, qui est de 0.94 : 1 seulement, nous serons frappés de la différence très-prononcée existant entre ces deux rapports. Pour l'Europe et l'Asie boréales, la proportion est respectivement de 1.5 : 1 et 1.3 : 1 ; pour l'Angleterre enfin, elle est de 1.3 : 1. Nous ne nous appesantirons pas davantage sur la singularité du rapport que nous venons de signaler ; nous nous bornons à la faire ressortir.

Nous réunirons, en dernier lieu, les chiffres de chaque saison ; ils se présentent comme suit :

Hiver	87
Printemps	43
Eté	43
Automne	91

La concordance de ces nombres mérite aussi de fixer l'attention : le printemps et l'été offrent des résultats complétement identiques, tandis que l'hiver et l'automne ne diffèrent que de 4 unités.

Nous terminerons les quelques observations qui précèdent, en faisant remarquer que nos connaissances sur la constitution géologique de la Nouvelle-Angleterre ne sont pas encore assez avancées, actuellement, pour permettre de donner dès à présent une explication plus ou moins satisfaisante des résultats curieux que nous venons de citer brièvement ; mais il est à espérer, ainsi que le disait M. Brigham en terminant son mémoire, que l'étude entreprise récemment par les géologues officiels des États-Unis pour arriver à connaître exactement le sol américain, jetteront bientôt une lumière toute nouvelle sur le sujet qui nous occupe ; c'est alors surtout que l'on reconnaîtra l'utilité exceptionelle des nombreux matériaux réunis avec tant de peine par MM. Perrey et Brigham, et que l'on sentira toute la nécessité d'avoir des observateurs habiles et exercés, recueillant avec soin, sur chaque manifestation volcanique qui se présente, les moindres données qui pourraient être profitables à la séismologie.

Bruxelles, *ce 21 décembre* 1872.

[1] M. Perrey avait déjà signalé ce fait dans son *Mémoire* cité plus haut.

VIII. Embryology of Terebratulina. By Edward S. Morse.

With the great impulse given to the study of Zoölogy through the labors of Charles Darwin, renewed effort has been made to work up the embryology of those forms which have rendered so little satisfaction from the study of their mature characters, and thus through the labors of European naturalists new light has been thrown upon the developmental history of Sagitta, Amphioxus, the Tunicates, and many other aberrant groups. And now while the embryology of nearly every prominent group has been more or less studied, and important relations revealed that would have otherwise been obscured, little or nothing has been done to throw any light on the embryology of the Brachiopods, a class represented by thousands of species in past times, and one of which we have the earliest records in the rocks.

This dark portion in the history of the Brachiopods seems all the more strange when we recall the many beautiful monographs of various genera of Brachiopods published since Cuvier's famous memoir, in the year 1802, on Lingula, and when it is remembered that a hundred and more species still exist in the seas at present. What little has been accomplished in this field, however, has shed great light on the natural affinities of the class, and it may be well briefly to recall what has already been done in order to make this portion of their history more complete.

To Oscar Schmidt is due the credit of giving the first figure of a larval Brachiopod. In the "Zeitschrift für ges. Naturwissenschaften," 1854, p. 325, he gives a description of the embryo of some species of Terebratula collected in the North Sea. Accompanying this description a simple figure was given. In this the embryo shows a deep constriction in the centre, the free or cephalic portion being wider than the posterior half, which is abruptly truncate at the end, and he infers, and rightly too, that at this end the embryo becomes attached. I add a brief translation of his description.

> The embryos of the Norwegian Terebratula observed by me differ remarkably from the embryo Lingula as described by Owen. They resemble a *Buastrum* composed of unequal halves; the round end seems to be the anterior. The somewhat narrower hinder portion extends into two projections. In none of the ovaries examined by me — for in these were the embryos found — had the development gone farther. In the perfect ignorance in which we now are with regard to the development of Terebratula, every small contribution towards clearing up this question is acceptable.[1]

[1] The allusion to the embryo Lingula of Owen has reference to Prof. Owen's memoir on the Anatomy of Terebratulina, forming the introduction to Davidson's British Fossil Brachiopoda, published by the Palæontolographical Society, London. On Plate I. of the Introduction, Owen figures five eggs of *Lingula anatina*, which he supposes are impregnated ova. In one egg he suggests the rudiments of a peduncle. The egg, as it escapes from the ovary by dehiscence, often presents the appearance figured by him, from the thin membrane still adhering to the egg after its rupture, and consequent separation, from the cluster.

To Lacaze-Duthiers, however, is due the credit of first presenting several stages in the embryology of a Brachiopod. In a memoir[1] upon the curious form Thecidium, from the Mediterranean, he figures the egg, as well as several subsequent stages in the early history of the embryo. These were found in a pouch attached to the cirri and contained within the pallial cavity. The embryo is first divided into two transverse segments, then into three, and finally into four segments. In one embryo he found two red ocular points upon the cephalic ring, in another four red eye spots occurred.

In one figure he represents the rings contracted upon each other, as will be seen to be the case with the embryo of Terebratulina. As before, I shall give the reader a condensed translation of the paper.

The youngest egg studied had already a somewhat pyriform and elongated shape. The most striking fact was the size of the cells composing it, and which themselves enclosed a great quantity of granules of relatively very large size. The cells no doubt were the result of segmentation, and the granules must have appeared during the first movements of embryonic activity, for the vitellus had only very minute granules.

In the next stage frequently seen after the preceding, and which I have observed in the same lot of young, the embryo divided into two lobes, the larger being always attached to the *suspensory filament*. In the embryo so divided by a circular furrow, perpendicular to the longer axis, the mass has a yellow tint, and is no longer composed of large cells, but is filled with yellow granulations much finer, and enclosed in smaller cells. In the smaller lobe a clearer space is seen, where the cells are filled with nearly colorless granules. On each side of the larger lobe also, and very near the transverse furrow, are two transparent spaces smaller than the preceding, but similar in other respects.

The larger lobe, attached, as stated, to the *suspensory filament*, is the anterior; the faces cannot yet be distinguished; but later it is possible to recognize the superior or inferior aspect.

The development, therefore, commences by the appearance of the two lobes, one the anterior, with two white spots, and the other with a single clear spot; later other spots with less coloring matter appear. Thus there appears near the point of attachment, on each side of the peduncle, a clear white spot, then the two lateral, spots above referred to, grow longer and obliquely extend towards the centre of the lobe.

Between these two last spots, on the line of separation between the lobes, the colored granules accumulate and form these lobules, the median later extending toward the posterior lobe.

The posterior lobe itself does not increase in proportion to the rest of the embryonic mass, but the transparent spot begins to show what it will later become. It extends towards the place where the lobules commence, then it becomes depressed in the middle, and will form, in fact, a real depression. There is still a gap between this and the succeeding stage to be described. The two white lateral bands, near the separation of the lobes, are traces of the formation of a new lobe, for the anterior lobe divides into two by a transverse furrow, and these two anterior lobes always remain relatively very large, the posterior changing but little.

At the time when this division takes place, toward the point of attachment where two other little clear spots have been seen, a lobule rises, which forms the counterpart of the little primitive posterior lobe. Thus the embryo is composed of four portions, two large in the middle and two smaller at the ends.

If the embryo is examined on all sides, it is soon seen that the two poles of the ovoid embryo are bent towards each other on one side, as if the two anterior lobes were curved over towards the two posterior. The concave face may be considered as the inferior, and the convex, the dorsal aspect.

The insertion of the suspensory peduncle is on the dorsal side of the anterior extremity, on the back of the little anterior lobule, not far from the edge of the second lobe. This peduncle is cellular, and composed of very distinct elements, and easy to recognize. The embryo is, therefore, suspended by the back of the head.

The inferior side of the anterior lobule is flat and somewhat quadrilateral in the most developed embryo seen; near the middle is a sort of oval longitudinal slit, which appears to be the mouth, although I have never seen particles of coloring matter, which I have put into the surrounding liquid, penetrate this opening, but indeed the embryos are still too young to feed.

[1] Annales des Sci. Nat., 4e Serie, Vol. xv., p. 317.

On the inferior side also of the lobule, somewhat deeply seated in the tissues, appear some red dots symmetrically placed on each side. These spots I believe to be eye spots; they are sometimes four in number, and sometimes only two. The presence of these spots and of the slit, lead me to consider this extremity as anterior.

The second, or large, anterior lobe is swollen behind, and nearly flat beneath. Its posterior edges run obliquely backward to form a very obtuse angle, hardly closed on the ventral side of the large posterior lobe, extending towards the angle made by the posterior lobule, which seems to be hollowed out with a wide depression.

The embryos, when the peduncle is broken, swim and whirl round by means of the cilia clothing the lobes. The anterior extremity moves forward always. The embryos are very contractile, so that, often on meeting an obstacle the longitudinal diameter becomes shorter than the transverse, the two extremities contracting towards each other. The cilia then stop and seem to disappear.

It has not been possible to carry the observations farther.

To sum up, then, on the inferior aspect one of the most advanced embryos shows four eye dots, as well as a distribution of the yellow material in the midst of the large anterior lobe, which reminds one much of the origin of the liver in the Acephala or Gasteropoda, and it is probable that the alimentary tract is hollowed out in the middle of these yellow granules, so that the secretory lobules of the liver of the adult Thecidium are foreshadowed in these series of little packets.

In the early summer of 1872 I was fortunate in tracing the embryology of Terebratulina so far as to carry the embryo to a form with three well marked and deeply constricted segments, and saw enough at that time to convince me that the embryo became attached by its caudal segment. These meagre results were published in Silliman's Journal.[1]

Some interesting features, however, had been brought to light in studying the early stages of certain Brachiopoda, the most important of which were presented by Fritz Müller in a note published in Reichert und Du Bois-Reymond's Archiv. 1860, p. 72, and a subsequent note in Wiegmann's Archiv, 1861, p. 53. These notes referred to the early stages of a form supposed to be Discina, collected at Santa Catharina, Brazil. I subjoin the notices which were published in the Annals and Magazine of Natural History, 3d series, Vol. VI., p. 310.

"Dr. F. Müller has sent from Brazil the description of a larva belonging undoubtedly to a Brachiopod, which is the more interesting, as the Brachiopoda are the only Mollusca regarding the development of which we have no information.

"The larva in question is a small, perfectly orbicular, bivalve Mollusk. The two valves are similar, but unequal in size, the dorsal valve being the largest. At the place of the hinge a small oval plate is placed transversely between the two valves of the shell. The mantle is gaping all round. Five pairs of very stiff setæ, of which one is much stronger than the others, and curved backwards, project at the periphery. They originate in the mantle of the ventral half; at least this is the case with four of them. A series of finer setæ spring from the circumference of the mantle of the dorsal valve, and curve down upon the outside of the ventral valve. The animal, as well as the shell, would be divided into two symmetrical halves by a plane drawn vertically through the middle of the hinge. The body, which is furnished with an alimentary canal, two auditory capsules, and two eyes, fills the posterior half of the space between the valves. The anterior half is occupied by four pair of cylindrical arms, between which a rounded knob is situated. Behind the knob the mouth is perceptible.

"These four pair of arms are supported upon a common peduncle, at the extremity of which, therefore, the mouth is placed. The arms are covered with a very well developed ciliary coat, by the agency of which the little animal swims. The reproductive and circulatory organs are wanting.

"During natation the mouth is always directed forwards, which is in favor of the generally received opinion

[1] Am. Jour. Science and Arts, IV., 1872, 262.

as to the anterior and posterior regions in the Brachiopoda. It is, in fact, now evident that the Brachiopods are *depressed* animals, having an anterior or ventral, and a posterior or dorsal valve. MM. Agassiz and Vogt are therefore wrong in regarding them as *compressed* animals like the Lamellibranchiate Mollusks; that is to say, as animals having a right and left valve.

"The larva, moreover, can not only swim, but also creep. This latter mode of progression is effected by a sort of rotation of the ventral valve alternating to the right and left. In this movement the animal pushes by supporting itself principally upon the strongest of the bristles above mentioned."

In Wiegmann's Archiv, Dr. Müller communicates additional observations on the larval Discina, a notice of which follows from the Annals and Magazine of Natural History, 3d Series, Vol. VIII., p. 505.

"In the Annals for October, 1860, p. 310, we gave a short abstract of a description of the larva of a Brachiopod observed by Dr. F. Müller at Santa Catharina, on the coast of Brazil; he now adds some further details from repeated observations in the summers of 1859 and 1860. The larva appears to occur late in the summer, from February to April.

"When the little animals are placed in good-sized vessels with pure sea-water, they soon ascend slowly; the slightly gaping shells stand perpendicularly, the hinge-margin downward; close to the anterior margin the eight arms spread out horizontally like rays, with their tips slightly bent downwards; and the roundish knob situated between the uppermost pair projects beyond the plane of the arms. In this posture they move slowly about near the surface. When strongly shaken, or sometimes without any perceptible reason, they retract the arms and close the shells, which then slowly turn over and sink to the bottom with the free margin downwards. If the arms be again protruded, the hinge-margin also again turns downwards.

"The duration of this state never exceeded five to six days, and in general the larvæ adhered to the bottom or sides of the vessel in a still shorter time. When they adhered to the sides, the mouth was always directed downwards; the ventral shell was strongly drawn forward until its anterior margin reached or passed that of the dorsal shell; the transversely oval plate, previously concealed within the shells (the peduncle), was protruded, apparently twisting around the notched hinder margin of the ventral shell, so that its anterior margin became posterior. For a day or more the animal remains contracted and quiet; then, the shells being slightly opened, the arms are half extended, and strike inwards, one or more at a time, just as in the marine Bryozoa. In a few days new bristles appear at the anterior margin, in the space left between the more delicate setæ of the dorsal shell. In a week the author counted twenty of these, mostly belonging to the dorsal shell. The longest were 0.8 mill. in length, straight, colorless, 0.006 mill. in thickness at the base, terminating in a fine point, unjointed and distantly feathered with fine lateral setæ 0.02 mill. in length. The principal change in the soft parts consisted in the retrogression of the organs of sense. The eyes had become broken up into groups of about ten black points; the previously spherical auditory vesicles were shrunken into longish sacs, closely surrounding the otoliths. In somewhat older animals there was no trace of the organs of sense, although they had not lost their sensibility to light.

"One of the larvæ lived for a month after its adhesion; but from the lapse of a day before its death was noticed, the soft parts had become greatly decomposed. The older bristles of the free larvæ appeared to be still present, as also the plumose bristles of the anterior margin. Besides these, there were on each side, about in the middle between the median line and the origin of the great bristles of the fourth pair, straight, smooth bristles, 0.2 mill. in length, projecting obliquely backward, little thicker than the strong posterior setæ, but with a much stronger outline.

"It is remarkable that in two years the author has repeatedly captured free-swimming larvæ which had evidently advanced further in their development than the oldest of those which had already fixed themselves. They were all destitute of the transversely oval plate, and of every trace of organs of sense; the plumose setæ of the anterior margin were also wanting, as were, more or less entirely, the older bristles. Of the more delicate bent bristles, some were usually still present, and these appeared to be unabbreviated, so that the missing ones had probably been lost by shedding. The stronger bristles, on the contrary, are gradually absorbed at the base; at least this is the case with the fourth pair; these were repeatedly met with of about half their proper length; the stalk, with its fusiform dilatations, had disappeared, while the apex remained readily recognizable by its peculiar curvature and denticulation. In a still older animal about a fifth of the length was still present, so that it no longer extended beyond the margin of the shell. This animal (the oldest examined by the author) had lost all the older setæ, except the small residue. On the other hand, the two straight, smooth bristles, which in the oldest attached animals scarcely began to protrude from the shell,

had attained a length of double the diameter of the shell, and being inserted into thick muscular sheaths were strongly and rapidly moved by the animal, sometimes spread out horizontally, sometimes again crossed backwards.

"During this complete change of the setæ the soft parts had undergone no essential alterations. The roundish stomach, reaching from the front to the middle of the longitudinal diameter, still showed the two dark spots of the young larvæ, which remind one of the similar spots in the larvæ of some Bryozoa. From the back of the stomach sprang the intestine, which bends under the margin of the stomach to the right, and then forwards, terminating about the middle of its right side. The œsophagus goes from the front of the stomach straight forward half way to the front of the shell, and then bends downward, so that the mouth lies close to the stomach. The arms, especially the two middle pair, had become longer and slenderer, and the knob between the anterior pair had diminished in size. No vessels or pulsating heart were recognized. — Wiegmann's Archiv, p. 53, 1861."

In the year 1869 I communicated to the American Association for the Advancement of Science the results of a study of the early stages of *Terebratulina septentrionalis*, made at Eastport, Me., in the early part of that year. This was afterward published in the Memoirs of the Boston Society of Natural History, accompanied by two plates.

In this memoir I showed the incipient cirri, seven or eight in number, and the gradual development of the complicated arms, the unfolding of the hepatic cœca from two folds upon the walls of the digestive cavity, the character of the shell structure, etc. And these two papers comprised all that has yet been done as to the early stages of the class.

A wide gap, however, has existed between the free swimming Annelidan larva clothed with cilia and the attached form revealing its Brachiopodan character in the presence of a dorsal and ventral plate, and the presence of cirri. After repeated visits to Eastport, almost solely for this purpose, I have at last succeeded in closing this gap, and in this paper I hope to make plain the history of the development of the dorsal and ventral areas, the peduncular attachment, and the relations the different parts of the mature animal bear to the embryonic segments, as well as to present some new features in the early stages of the species.

For two seasons I have found Terebratulina spawning at Eastport during the last of May and the early part of June. It is probable that they spawn through the season, since I have found them depositing eggs in April. At my request Mr. Rathbun made several observations during the summer, to ascertain how long the species continues to ovulate, and he informs me that on the only dates he collected them, namely, June 26, July 12 and Aug. 29, they were freely discharging their eggs. It is best, however, to study them as early in the season as possible, as the water in which the eggs develope must be kept at a low temperature, and this essential condition can be most easily accomplished at Eastport in May, where the temperature at that time ranges from forty to sixty degrees Fahrenheit.

The manner in which I secured the eggs for study was simple enough. Several shallow glass dishes were prepared by painting the bottoms black. Having dredged a lot of specimens, I arranged them in a circle around the edges of the dish, with their anterior ends pointing toward the centre of the dish. By arranging the specimens in this manner the difference in the sexes becomes at once apparent.

The eggs are discharged from the anterior margin and drop just beyond the pallial membrane, hanging in clusters from the setæ, and covering the bottom of the dish in the immediate vicinity of the animal, presenting the appearance of a white powder, though with a simple lens the individual eggs are plainly seen. They are opaque and spermaceti white in

color. In the course of a few hours they become clothed with cilia, and while many of them slowly move away, some remain and perish, or, at least, show no sign of development. These are probably not fertilized.

The sexes are separate, and the spermatozoa are discharged by the males in the same way that the eggs are discharged by the female, but whether the eggs are fertilized after they have left the parent, or before, I was not able to determine, as different lots of eggs behaved differently after their escape. In some cases the eggs did not appear to be locomotive until two or three days after their discharge, while in other cases they became active on the day of their discharge.

Great care must be taken to change the water every day, since the water soon becomes vitiated, and Paramæcia rapidly develope and appear to feed upon the embryos. The temperature of the water must be kept as near as possible to that from which they were taken. In drawing and replacing the water a glass syphon was found the best, as in this way the embryos were not disturbed, though some skill was required during the active natatory condition of the embryos, to prevent them from leaving the dish also.

The development of the embryo presents a series of well defined stages, and I shall consider each stage in turn. In the first stage the embryo becomes widened at one end. The segments are barely indicated, the posterior end is the widest, the anterior portion is ornamented with a conspicuous tuft of long cilia, so peculiar to the embryos of many worms. The embryo is also clothed with vibratile cilia, and in this condition slowly moves along the bottom of the dish without rising from it, or remains quiet. In the second well marked stage the embryo is divided into two prominent segments, these expand and contract upon each other slightly, and the cephalic segment has the power of partially bending from side to side. In this stage the embryo is most active, swimming rapidly in every direction and turning abruptly about. The œsophagus also becomes dimly defined. In the third stage the peduncular segment is developed and projects from the posterior portion of what can now be called the thoracic segment. At this stage the embryo either remains immovable upon the bottom of the dish or slowly moves about. In two cases delicately barbed setæ to the number of thirty-five projected directly backward from the peduncular segment. In the fourth stage the embryo becomes attached by means of its peduncular segment. The embryo is still clothed with cilia, though the long pencil of cilia has disappeared. The head is closely drawn to the thoracic segment, which becomes wider in transverse diameter, so as nearly to hide the peduncle. In the fifth stage the thoracic ring commences to fold, or turn upward upon opposite surfaces of its circumference, so as to gradually enclose the head; one fold being made slightly in advance of the other represents the larger or ventral valve. In this stage appear clusters of barbed and deciduous setæ upon the anterior margin, and in a later portion of this stage the first hardened areas of the dorsal and ventral plates make their appearance, and the cirri appear as blunted papillæ about the mouth. In the sixth stage the shell becomes rounded, the peculiar scaled structure makes its appearance, and the formation of tubules perforating the shell, and permanent setæ takes place.

In another memoir I hope to present the characters of the genitalia of the Brachiopoda. I will state here, however, that the eggs not only fill the large pallial sinuses, but hang in clusters from the genital band; from these parts they escape by dehiscence, and float freely in the perivisceral cavity. The anterior perivisceral wall is sufficiently trans-

parent to allow one to watch the eggs as they are gradually drawn to the infundibuliform orifices of the oviducts, and to secure them as they escape by the external orifice of the oviduct. In parting the shells for this purpose great care must be taken not to open them too far, as the parietal wall will rupture, and from this opening the perivisceral fluid and eggs will escape. The eggs are not uniform either in shape or size, though a distinct granulated membrane, the ovishell, is formed while the egg is contained in the perivisceral cavity. Segmentation is next seen, first as a few indentations upon the periphery of the egg, until finally the whole egg presents a mass of cells, as shown in Fig. 11. The egg next assumes an oval shape, becomes ciliated, and in several eggs at this stage a dim opening extending to the centre midway between the opposite poles of the egg was seen — whether this was the micropyle or the scar from which the egg escaped from the ovisac I could not determine; gradually the egg becomes widened at one end, which is to be the base, or posterior pole of the embryo. A long pencil of cilia springs from the smaller anterior end, so characteristic of the Annelid embryo.

First Stage. From some of my drawings it would seem as if the peduncular ring consisted of the primary posterior pole of the egg, the thoracic ring widening and enclosing it. At all events the thoracic ring forms the widest portion of the embryo, directly in front of which a second fold makes its appearance. Whether this is an indication of another ring I could not make out; later, however, it merges into the base of what is to be the cephalic ring, and the deep constriction that is soon to follow occurs between this fold and the thoracic ring. An end view shows the thoracic ring slightly flattened while the cephalic ring preserves its circular outline. In this condition the embryo swims slowly about. This ends the first stage.

Second Stage. In this stage, and one that seemed of the longest duration, a matter of three or four days, the embryo is quite elongated, and is divided by a deep, transverse line into two unequal halves, the head segment being the smallest. At this stage it is the most active, no longer moving slowly along the bottom of the dish, or remaining motionless, but ceaselessly swimming in a rapid manner back and forth through the water, and abruptly turning about; the segments expanding and contracting upon each other, and the head bending from side to side, the thoracic segment often being transversely wrinkled by this bending. A peculiarity of the embryo at this stage consists in the various external outlines assumed by the embryo, presenting also different proportions, as shown in Figs. 18, 19, 20 and 21, drawn from the same embryo. The first definite trace of internal structure now occurs in the formation of the alimentary tract, appearing as a long, narrow tract running from the thoracic to the cephalic ring, closed posteriorly, but blending with the cell contents of the cephalic segment. A clear interspace is also seen at the anterior portion of the thoracic ring. What appeared to be an opening in the posterior end of the embryo was seen in some cases.

During all these stages, from the egg upward, great difficulty arises in making out any feature of internal structure, owing not only to the minute size of the objects, but to their opacity, and what little has been made out has in most cases been done by slightly compressing the embryo.

During this active swimming stage in some embryos is seen a structure that appears to be the incipient peduncular segment. In Plate VIII., Fig. 25, and Plate IX., Fig. 78, a rounded process is seen protruding from the thoracic segment, the walls of which extend as far as

the division between the two segments. The alimentary tract is seen here, its anterior portion blending with the cell contents of the cephalic ring, while posteriorly it hangs in the cavity supposed to be the incipient peduncular segment. Whether this is the proper interpretation I cannot say, and the difficulty arises from the fact that in some embryos farther advanced this structure does not appear. Thus in Fig. 83, Plate IX., an embryo is shown in which no sign of the peduncle appears, and yet it seems in advance of the one just described, in showing the widening of the thoracic ring, one side of which shows a bulging which represents the future ventral fold. An irregular cavity is thus left by the bulging of the external wall, and in this cavity at a later stage I have seen the circulation of minute granules. Within this cavity is another cavity bordered by thick walls which hang from the suture dividing the two segments. The alimentary tract is seen suspended between the two segments, and showing a faint connection with this cavity. The cephalic segment shows no change in its granular contents save the presence of the alimentary tract. The parts surrounding this tract are continually contracting in a spasmodic way, though no trace of a muscular band could be detected. The interpretation of these cavities has perplexed me exceedingly. The most reasonable supposition is that the outside cavity in the thoracic ring marked *pl.* represents the cavity from which the pallial sinuses are to arise; in this cavity I observed the circulation of minute granules, as before stated. The cavity within surrounded by thick walls is the peduncular cavity, and a faint interspace running from the upper part of this cavity to the base of the digestive tract appears to be the opening up of the peduncular cavity into the cephalic segment, a cavity in which the stomach is afterwards to be suspended, and this may be called the perivisceral cavity. In Lingula and Discina the peduncular and perivisceral cavities are in open communication. In Discina the large azygos opening is very apparent. Future study will undoubtedly modify the interpretation of these cavities, and possibly show it to be altogether wrong.

In the hundreds of embryos examined, a few only were of sufficient transparency to reveal any structure within, and from this stage onward, the difficulty in this respect increases, as the embryo becomes more opaque, and with the after formation of the dorsal and ventral plates, combined with their minute size, render the study of their internal structure almost hopeless. Plate IX., Fig. 86, represents the peduncular portion just ready to protrude.

Third Stage. In this stage the peduncular segment has made its appearance as a rounded knob, varying in size in different embryos. Soon after the appearance of the peduncle, granules are seen gathering about its end, apparently adhering to the mucus secreted by it. Soon afterward adhesion takes place, the embryo remaining fixed when the water is disturbed, though even before the embryo becomes attached, the bulging of the thoracic ring becomes more conspicuous, leaving a clear cavity within. The walls of this bulging portion present a number of highly refractive granules scattered evenly over its surface. This portion first loses its cilia (Plate IX., Fig. 87) just before attachment; the embryo becomes sluggish, or at least, in most cases, ceases to swim actively. In two cases a cluster of delicately barbed setæ, to the number of thirty-five, was seen to project directly backward from the posterior end (Plate IX., Fig. 79). That these were very transient is evident from the fact that they were only observed in two cases out of three hundred and fifty-two different embryos examined. The head continues to move freely, and shows a slight fold at its base. As the head contracts, the thoracic ring widens; this is shown in Plate I., Figs. 42, 43, where the same is sketched with the segments extended and

contracted. In many embryos the thoracic ring presents an indentation on one side, as if the ring were a band partially uniting at this place. The peduncle gradually widens at the end into a sucking disk, and at this time the embryo becomes permanently attached.

Fourth Stage. The embryo now settles down upon its base of attachment, the thoracic segment widening and flattening, and appearing pressed to its point of support, so as to conceal the peduncle. The head is closely pressed to the thoracic segment, the clear space within having disappeared, and the head only appearing ciliated. And now commences the most important portion of the developmental history, in which, for the first time, we become acquainted with the development of the dorsal and ventral plates.

Fifth Stage. The thoracic segment commences to fold upon both sides of the head, and these are the dorsal and ventral folds. Gradually the head is enclosed by the folds. In this portion of their history I was peculiarly fortunate in securing hundreds of examples just after they had become attached to adult Terebratulina. These I studied in their natural positions. In some cases the Terebratulina had been torn from Mytilus, to which they had been attached. The peduncular disk brought away a layer of the black epidermis of the Mytilus, and to this surface many embryos conveniently became attached, and against this black background the pure white embryo showed to the best advantage. At intervals the Terebratulina would twirl its peduncle, thus presenting the embryos in different positions, all of which I instantly sketched. I have a great many drawings at every stage of this interesting growth, some of which are given on Plate VIII., Figs. 47 to 77, inclusive.

One fold grows more rapidly than the other, and I infer that this is to be the larger or ventral plate. The head appears to be gradually engulfed, as it were, though for a long time protruding beyond the dorsal and ventral folds. The folds also present for a long time a thickened and rounded border. The inner edge of what I suppose to be the dorsal valve, shows a distinct notch in the median line in some (Plate VIII., Fig. 63). As the dorsal and ventral folds develop, the embryo becomes elevated upon the peduncular stalk, and the attachment becomes so firm that a forcible stream of water falling upon them does not detach them, indeed a point of a needle, or a stiff camel's hair pencil, was found necessary for the purpose, and in the removal, the parts were so soft as to break down in most cases. The mouth also makes its appearance at this time, the head for a long time occupying the area enclosed by the two folds. As soon as the embryo rises upon its peduncle it drops partially over to one side, the ventral or larger area being uppermost.

The hinge margin is broad and slightly rounded when looked at from above; a side view, however, presents a wide and flattened area, as is shown in some species of Spirifer, and the embryo for a long time assumes the position that the Spirifer must have assumed. The dorsal and ventral folds close up on the sides, and their edges become sharper; the future lateral openings of the shell gradually extend to the base. From above, the thorax is wider than long. Starting from a broad base it widens gradually to the anterior margin, which is nearly straight, to which it joins by a short curve. A heart-shaped corneous shell is formed even at this early stage, for in several cases I met with it where the softer portions had been removed by Paramæcia. (See Plate VIII., Fig. 68.)

Before the folds have closed over the head, four bundles of setæ appear; one bundle containing from seven to nine setæ springing from where the folds unite laterally. These stand out at nearly right angles to the longitudinal axis. The other bundles containing from two to four setæ, spring from a point midway between the first bundles and the

median line anterior. Thus the embryo possesses from twenty to twenty-five setæ springing from the anterior margin. The larger and lateral bundles of setæ are the first to make their appearance. They are nearly as long as the entire length of the embryo, and are *delicately barbed and deciduous*. Upon pressure of the embryo they readily separate from their base of attachment. The dorsal valve is flattened, while the ventral valve is rounded, as before remarked. The first evidence of hardened plates appears in the later stages of these forms, for upon crushing the embryo in the live cage a number of angular fractures appear. (Plate II., Figs. 89 and 91.)

Fig. 85, Plate II., presents a view of an advanced stage, in which the relative position and character of the deciduous setæ are shown.

Fig. 81, just above, represents the same embryo as it appeared when slightly crushed. The manner in which the contents burst out from the shell still held by the membrane, as in a sac, the fracture of the shell and the detached setæ, are all instructive. Besides the minute granules which make up the substance of the embryo, larger cells, to the number of twenty-five or more, are seen scattered through the mass. In a slightly advanced stage, Fig. 90, Plate II., the mouth shows on each side a rounded papilla, the first appearance of the cirri. The mouth is prominent, and flush with the anterior borders of the pallial membrane; this is also shown in Fig. 82.

Fig. 91 represents the appearance of Fig. 90 crushed. Here the incipient cirri show as two prominences, one upon each side of the mouth. The shell fracture is also more apparent. As the embryo advances in growth the outline changes, having at first a transversely semicircular outline with the posterior margin straight, as in Leptæna. It gradually elongates, and commences to widen its anterior margin, as in Fig. 93; it becomes well rounded as in Fig. 88, and at this time is seen a difference in the length of the dorsal and ventral plate, and for the first time appear concentric lines of growth. The deciduous setæ, at this stage, separate at the slightest handling of the embryo, and as in every case the figures on the plates are exact fac-similes of my original drawings, the setæ are not shown in Fig. 88, as they dropped off in removing the specimen to the live box. A stage of the same age, or slightly later, is shown in Fig. 94, and this stage immediately precedes the formation of the scaled structure of the shell. Its outline is quite unlike any adult Brachiopod known. It is longer than broad. The posterior margin is quite broad and rounded. The anterior margin is twice the breadth of the hinder margin, semicircular, and abruptly rounded where it meets the lateral margins, which are incurved. The larger bundles of setæ project at the point where the anterior curved margin joins the lateral margin. (See Fig. 94.) A distinct triangular area is seen within, which represents the head, below which the digestive tract is faintly indicated.

Sixth Stage. The embryo has now discarded its deciduous setæ, and for the first time the permanent setæ make their appearance, as well as the peculiar scaled structure of the calcareous shell, and with these new features that of the peculiar tubules perforating the shell must be added.

Fig. 96 represents a somewhat more advanced stage than Fig. 94. The form is now bluntly oval, its posterior margin prominent and bluntly rounded. In general contour it recalls Siphonotreta, placed in the family Discinidæ by Davidson, a genus not occurring above the Silurian. Seven prominent setæ longer than the shell now spring and diverge from the anterior margin. These are not barbed. The shell now plainly shows its scaled

structure, and within is seen four cirri, below which the digestive cavity occurs. The tubules first formed are three in number, of large size, and are arranged in a triangular figure, the two forming the base of the triangle occurring midway between the front and hinder portions of the head, the other tubule being near the anterior margin.

The tubules, or pores first formed, present some new and interesting features. In every case examined, the first that make their appearance are three in number, and are invariably arranged so as to form a triangle as shown in Figures 95, 96 and 105. They are also much larger than those subsequently formed. They are oval in shape, and within their borders a circular, granulated plug of a reddish yellow color is seen, between which and the outer border of the tubule a clear space is visible. From twelve to fourteen hairs of various lengths, some of them three times as long as the diameter of the pore, spring from the margin of the granulated disk, and radiate in every direction. That these are veritable hairs and not minute tubules in the shell, or any internal markings, I proved in a very simple manner. First I made an exceedingly careful drawing of the tubule, showing exactly the position of each hair, and then brushing the pores slightly with a delicate camel's hair pencil I again made a careful drawing of the same pores, using the same objective, $\frac{1}{5}$ Wales. The hairs were found in every case to have changed positions, being bent in different directions. Fig. 100, *a*, represents a drawing of the tubule before brushing, though in this the hairs were bent in handling the specimen, and Fig. 100, *b*, represents the same pore after brushing. Next summer I hope to study this peculiar structure of the tubule with higher powers. The tubules subsequently formed are much smaller in size, showing, however, the same hairs in less number radiating from them.

Whether there is any relation between these veritable hairs and the radiating lines surrounding the tubules, as described by Queckett and Carpenter, and regarded by them at one time as representing cilia, I cannot say. In this connection, however, it is interesting to recall other views on the subject.[1] It is more probable that the tubules are simply organs of general sensibility. In the test of Crustacea similar tubules occur, which penetrate to the vascular layer beneath, and are regarded as endowing the test with a general sensibility.[2] The subsequent tubules appear to make their appearance in a certain symmetrical order as shown in Fig. 105, one occurring on each side of the peduncle. In Fig. 102 a distinct area is seen, from the anterior surface of which the cirri spring, and from the borders of which the scaled structure of the calcareous shell commences to form. This area has the same outline as the stage represented in Fig. 94. The cirri present coarse cilia as long as the diameter of the cirrus; the cavity within is large, on the outer border of which a few irregular granules are arranged in a single line. See Fig. 101, representing a cirrus from stage 102.

This brings the development of Terebratulina up to its "Early Stages," already described by me in these Memoirs.[3]

By comparing the early conditions of the embryo Terebratulina with that of Thecidium, described by Lacaze-Duthiers, a certain resemblance is observed, so far as the division of

[1] See an interesting paper of Prof. King on the structure of the tubules in the test of Brachiopoda, in the Memoirs of the Royal Irish Academy, Vol. XXIV, p. 439.

[2] See De Morgan on the Structure and Functions of the Hairs of Crustacea, Philosophical Transactions, Vol. CXLVIII, p. 805.

[3] Morse. Early Stages of Terebratulina. Mem. B. S. N. H., Vol. II., p. 29.

the body into segments, and their power of contracting upon each other is concerned, though the conditions under which they develop will be found to be entirely unlike. The egg of Terebratulina is discarded freely into the water to undergo its development, and possibly its fertilization outside the parent, while the embryo Thecidium is held attached within the pallial cavity, and separates only after it has undergone changes in advance of those found in the embryo Terebratulina after it has become permanently attached.

The presence of eye spots in the embryo Thecidium is another important difference, for though I examined hundreds of the Terebratulina embryos, yet in no instance were the traces of eye spots detected. On comparing the early stages of Terebratulina with that of Discina, we are at once struck by the marked differences between the two; Terebratulina becoming permanently attached by its peduncular segment long before a trace of the peculiar dorsal and ventral plates makes its appearance, or even before any definite structure shows within, while Discina swims freely in the water sometime after the dorsal and ventral plates, cirri, mouth, œsophagus and stomach, have made their appearance.

The long and protrusible œsophagus and head, bearing a crown of eight cirri, or tentacles, in Discina, as described by Dr. Müller, is unlike anything of the kind observed in Terebratulina. Their barbed and deciduous setæ, however, present similar features to those of the embryo Terebratulina.

The embryology of Lingula (which I hope soon to have the opportunity of studying on the coast of North Carolina) will undoubtedly afford stages similar to those observed in Discina. I have already studied, in the transparent plates of *Lingula pyramidata*, the character of the nucleus, and find it perfectly orbicular with a margin finely notched, and in certain fossil Lingulæ I have observed the same orbicular nucleus. With the other characters, in common between Lingula and Discina, we should expect to find similar features revealed in their embryology.

In considering the various degrees of persistence of embryonic features in the few forms we are thus far acquainted with, we are struck with the great difference in this respect between Discina on the one hand, and Terebratulina on the other. Thus, in Discina, attachment takes place sometime after adult characters make their appearance, the peduncle at first extending directly backward, as in Lingula. In Lingula, as I have heretofore observed, attachment never takes place, at least in *L. pyramidata*, the creature living loose in the sand; and this feature will probably be found characteristic of other Lingulæ when they shall have been carefully observed.

Thus we see in later geological forms, attachment taking place earlier in developmental history than in those of earlier geological times. Similarly in earlier geological times we find forms in which the dorsal and ventral plates are chitinous, and, as I have observed in *Lingula pyramidata*, of such transparency that the circulating fluid could be easily seen coursing through the sinuses of the pallial membranes, and in this latter species containing so little earthy matter that when dry they become twisted out of all shape, and even roll up like a leaf. With these facts it requires no hazardous supposition to conceive the primordial Brachiopods devoid of the dorsal and ventral plates, or furnished only with a semilunar membrane on the head, as in that curious annelid Umbellisyllis, described by Sars, and of a form that presented the annelidan characters less disguised by features that have heretofore prevented a right conception of their affinities.

As to the relations of the Brachiopods with the Polyzoa, some features of similarity are

seen between the embryo Brachiopod and the free embryo of Pedicellina, described by Van Beneden,[1] though the development of parts within a cœnœcium, and the formation of statoblasts are features quite unlike the Brachiopod. A roundabout relation might possibly be insisted upon through the Rotifera, in their winter ova.

After this paper had been made up into pages, Mr. Alex. Agassiz called my attention to the fact that Prof. John M^c^Crady had published in the Proceedings of the Elliott Society of Natural History of Charleston, S. C., a notice of a larval Brachiopod.

After a fruitless search among the libraries of Boston for a perfect set of the Proceedings of this Society, I learned that within a week Mr. M^c^Crady had made his home in Cambridge, having recently become connected with the Museum of Comparative Zoölogy. From him I learned that the original description and drawing was presented before the Elliott Society, at its meeting June 15th, 1860, but, owing to the war, had never been published by the Society. In the destruction of Columbia, S. C., by Sherman's Army, Prof. M^c^Crady not only lost his valuable library, but all of his scientific records, drawings and notes. After this irreparable loss, he drew up from memory a description of this Brachiopodan larva, and now generously allows me to make free use of this valuable manuscript, which contains the first and only observations on a larval Lingula ever made.

The creature in question was found by him either late in the fall of 1859, or in the spring of 1860, he cannot now remember which. It was found off Sullivan's Island in Charleston Harbor. The following is quoted from his manuscript.

"1st. The larva is a free swimming animal.

"2d. Its means of locomotion are large vibratile cilia, clothing the cirri of the arms, precisely as in Bryozoa.

"3d. It was provided with a bivalve semi-transparent horny shell, recalling the shell of Lingula, but with no trace of a foot stalk." (Mr. M^c^Crady adds in pencil that the form of the shell was flattened, and more ventricose than that of adult Lingula.)

"4th. In motion the valves were opened just enough to allow free play to the ciliated cirri of the arms, which (*i. e.*, the cirri) was thrust out beyond the shell rim.

"5th. The arms were never extended beyond the shell rim, but just within and along their margin.

"6th. The opacity of the body was such, that added to the cloudy semi-transparency of the horny shell, it was impossible to make out other details.

"7th. When the larva ceased swimming, the arms and their cirri were retracted, the valves closed, and the animal sank to the bottom."

By comparing the above description with that of Dr. Fritz Müller's description, given in the first part of this memoir, the closest similarity will be observed between them in their general appearance, their mode of swimming, and even to the manner in which, when at rest, they close their shells and sink to the bottom of the vessel in which they are confined. Mr. M^c^Crady assures me he has never seen Müller's description of the larval Discina.

It is interesting to remark that nearly at the same time, these two naturalists should make the first observations ever made on the embryology of the Brachiopods, if we except the very brief notice of Oscar Schmidt.

[1] Hist. Nat. du genre Pedicellina. Mém. Acad. Royal de Belgique. Tome XIX.

The expression of mine which occurs above, that the embryology of Lingula when known would agree with that of Discina, was in type long before I became aware of Mr. M'Crady's discovery.

The absence of setæ in the embryo, with the opacity of the valves, is an evidence that it was considerably advanced, for Müller described some of the larva observed by him as having lost the larger bristles.

In closing this brief memoir I wish to express my thanks to Mr. Richard Rathbun, who accompanied me to Eastport, and who assisted me in securing materials for study.

To Mr. Edward Burgess I am again under many obligations during the preparation of the paper.

My thanks are also due to Mr. Chas. A. Walker, who has with great fidelity and patience reproduced accurately my drawings upon steel.

Explanation of Plates.

PLATE VIII.

Fig. 1. A cluster of eggs from the genital band.

Fig. 2. A single egg encased in its capsule.

Figs. 3, 4, 5. Eggs from the perivisceral cavity immediately after their escape from the pallial sinuses.

Fig. 6. Highly magnified portion of the eggshell.

Figs. 7, 8, 9, 10 11. Eggs in various stages of segmentation.

Fig. 12. First ciliated stage.

Figs. 13, 14, 15, 16, 17. Successive stages of transverse division of embryo, showing long tuft of cilia at cephalic extremity.

Figs. 18, 19, 20, 21. From a single embryo, showing various outlines assumed while swimming.

Figs. 22, 23, 24. Different views of another embryo.

Figs. 25, 26, 27. Different embryos showing first appearance of caudal or pedunculer segment.

Figs. 28 to 36. Different embryos at the stage when the caudal segment becomes conspicuous.

Figs. 29, 30. Representing the same embryo contracted and expanded.

Figs. 37, 38, 39, 40, 41. Embryos just attaching themselves by their caudal segment.

Figs. 42, 43. Drawn from the same embryo: the first showing the embryo stretched to its utmost, the second the same contracted. (These motions would often follow each other rapidly.)

Figs. 44, 45. Embryos showing first appearance of ventral? area by the bulging of the thoracic ring.

Figs. 46 to 53. Embryos in various stages showing widening of thoracic ring, and its gradual growth toward enclosing the cephalic ring.

Figs. 54 to 61. Successive stages of the embryo showing formation of dorsal and ventral areas by the folding and growth of the thoracic ring. In Fig. 61 the head is still seen projecting from the dorsal and ventral folds of the thoracic ring.

Figs. 62 to 77. Succeeding stages of embryos drawn in various positions. The deciduous setæ appear in these stages.

Fig. 68. Dorsal and ventral plates of embryo, the contents having been removed by Paramæcia.

Note. The cilia constantly clothing the embryo have been purposely omitted except in a few cases, to save trouble in engraving. On the first appearance of the dorsal and ventral folds of the thoracic ring, the cilia disappear from that region. Figs. 18 to 77 were drawn with a $\frac{1}{10}$ objective of Smith and Beck; the embryos measure about the $\frac{1}{160}$ inch in diameter.

PLATE IX.

The figures of embryos upon this plate as follows: 78, 79, 80, 81, 82, 83, 85, 86, 87, 88, 89, 90, 91, 92, 93, and 94 were drawn with a Wales $\frac{1}{5}$ inch; a few of them are shown less magnified on Plate VIII.

Fig. 78. Free swimming embryo showing first trace of alimentary tract and peduncular segment.

Fig. 79. Free swimming embryo showing deciduous setæ projecting behind. This feature was only observed in two instances.

Fig. 80. Showing widening of thoracic segment, depression of cephalic segment, and first attachment of caudal segment.

Fig. 81. Appearance of embryo Fig. 85 after having been crushed. The embryo shell, apparently corneous, is split at the peduncular end. The membrane representing the head and cephalic wall is bulged out, with ruptures from which the cellular contents of the body are escaping, and the deciduous setæ are separated from their base of support.

Fig. 82. First stage in which the mouth makes its appearance, and dorsal and ventral plates become distinctly marked.

Fig. 83. Earliest stage in which definite internal structure was found. The peduncular segment characterized by thick walls is seen hanging in the thoracic or pallial cavity.

Fig. 84. Highly magnified drawing of deciduous setæ showing their barbed character.

Fig. 85. Showing arrangement of deciduous setæ, and contour of embryonic shell.

Fig. 86. Another stage similar to that shown in Fig. 83.

Fig. 87. Showing first bulging of thoracic ring and clear interspace within. This region is characterized by large granules marking its wall, and in first losing its ciliary lining. The bulging probably indicates the region of the larger or ventral valve.

Fig. 88. A stage slightly advanced from Fig. 85, showing change in outline, the anterior margin strongly ciliated. The deciduous setæ were easily dislodged at this stage, and were often lost in examination.

Fig. 89. A portion of shell of Fig. 88 crushed, showing by its fracture a harder consistency.

Fig. 90. Stage showing for the first time a primary cirrus or tentacle upon each side of its head.

Fig. 91. The same crushed, showing fracture of shell, and parts forced out by pressure.

Fig. 92. Stage similar to Fig. 85.

Fig. 93. A slightly advanced stage from Fig. 92, showing widening of anterior margin.

Fig. 94. A stage slightly advanced from the preceding, with a definite structure showing in the anterior portion of shell.

Fig. 95. Adult characters now assumed, permanent setæ now showing, and pallial cœca present.

Fig. 96. The youngest stage met with in which adult characters were present. The permanent setæ, seven in number, project from the anterior margin. The peculiar scaled structure of the shell is just appearing, and the primary pallial cœca are present. Within, the rounded stomach, and four tentacles are shown.

Fig. 97. Head, tentacles and stomach from an advanced stage. Figured particularly to show contour of parts about the head.

Fig. 98. A stage considerably advanced from Fig. 96, showing subsequent widening of the anterior portion of the dorsal and ventral plates.

Fig. 99. A setigerous follicle with its seta.

Fig. 100. *a*. *b*. One of the primary pallial cœca, showing appearance of fringing hairs. *a*. Showing the position of hairs before being disturbed by a brush, and *b*, the same after having been brushed with a delicate camel's hair pencil. These are from Fig. 105.

Fig. 101. A tentacle, or cirrus from Fig. 102, showing cavity within, and arrangement of calcareous particles, and relative size of cilia clothing it.

Fig. 102. A considerably advanced stage drawn to show relations of embryonic area, which is shaded. This portion corresponds to stage shown in Fig. 94.

Figs. 103, 104. Showing appearance of fringing hairs bordering pallial cœca.

Fig. 105. Advanced stage to show relative position and size of primary cœca and the first appearance of cœca upon that portion bordering peduncular opening.

In my Memoir on the Early Stages of Terebratulina, published by the Society, I take up the developmental history of Terebratulina from the stage represented in Fig. 105.

EXPLANATION OF LETTERS ACCOMPANYING THE FIGURES.

m, mouth.
œ, œsophagus.
s, stomach.
t, tentacles or cirri.
a, alimentary tract.
pl, pallial cavity.
pv, perivisceral cavity.
pc, peduncular cavity.
c, cephalic segment.
th, thoracic segment.
p, peduncular or caudal segment.
h, head.
ap, anterior parietal wall and head.
e, area of embryonic shell.
f, fold of larger, or ventral area.
pr, primary cœca.
ds, deciduous setæ.
es, embryonic shell.
x, foreign particles adhering to peduncle.

IX. The Birds of Western and Northwestern Mexico, based upon Collections made by Col. A. J. Grayson, Capt. J. Xantus and Ferd. Bischoff, now in the Museum of the Smithsonian Institution, at Washington, D.C. By Geo. N. Lawrence.

THE subjoined catalogue is the result of an examination of several collections of birds, made in Western and Northwestern Mexico within the past few years, and sent to the Smithsonian Institution for determination.

The largest and most valuable were made by Col. Grayson, principally in the vicinity of Mazatlan, where he resided, from which place, however, he diverged in several directions; the large number of species obtained by him give evidence of his great perseverance and devotion to the cause he had espoused. The next in importance are the collections of Capt. Xantus, made farther to the south, in the regions of Colima and Manzanilla. Mr. Bischoff collected only near Mazatlan. A few specimens were sent by Dr. Palmer from Guyamas, in the southern part of Sonora. There are no specimens from north of this last point, the extreme northwestern portion of Mexico is, in fact, a "terra incognita," zoologically speaking.

All these collections were submitted to me, for the purpose of giving a catalogue of them, by the officers of the Smithsonian Institution, who at the same time kindly placed in my hands the various notes and journals of Col. Grayson, together with very full biographies by him of many species of birds, from which I was authorized to make such extracts as I thought would add to the interest of the catalogue.

These biographies are exceedingly graphic and of great value, as they elucidate the economy of many species, of which comparatively but little was heretofore known; they show him to have been an indefatigable and close observer of the habits of birds. As a field naturalist he should take rank with Audubon. The biographies, although of great interest, are too extended to be copied at length, as the limit of this paper admits only of partial extracts. They are accompanied by one hundred and fifty plates of Mexican birds, of life size, faithfully drawn and colored. It was the intention of Col. Grayson to prepare full histories of all the species of birds of Western Mexico, together with characteristic drawings, for the purpose of publication at some future time, but unfortunately the completion of this design was prevented by his untimely death.

Although the list of species is quite large for a local fauna, Col. Grayson expected to add many to it, as he wrote in April, 1869, just prior to his unfortunate visit to the Isabel Islands, as follows: "But the field is not yet exhausted; before the end of this year I hope to be able to add many more species, especially from the region of the Sierra Madres Mountains in these latitudes, and which I have not yet explored."

There are no notes or observations from any collector, except from Col. Grayson, all of which are enclosed in quotation marks.

Fam. TURDIDÆ.

1. *Turdus ustulatus* Nutt.
" " Proc. Bost. Soc. of N. H., XIV., p. 276.

Tres Marias, Jan., 1865, Grayson.

"I found this bird quite abundant on the Tres Marias Islands when I was there in the months of January, February, and April. It was very shy and timid; this fact alone led me to believe that it was a winter visitant to this locality — a stranger.

"Since I made its discovery in this remote locality, I find that Prof. Baird, in his description of the above-named species (Rev. of Am. Birds, p. 18), states as follows: 'This species hitherto has not been noted as found outside the limits of Washington Territory and northern Oregon, nor as far east as the Rocky Mountains — the most eastern point being Chiloweyuck, (July 3, 1859, Dr. Kennerly), where it was found breeding very abundantly.'

"The important fact that it selects the Tres Marias Islands for its winter migrations, and is nowhere found on the main-land in this vicinity, is of extraordinary interest."

2. *Turdus grayi* Bp.
" " Proc. Bost. Soc. of N. H., XIV, p. 276.

Tepic, Tres Marias, Grayson.

"At times during the winter months it is abundant in the Tres Marias. Frequently met with in the *tierras calientes* of the main-land; I found it breeding near Tepic in the month of May. It is gregarious and semi-migratorius. There are many points of similitude in this species and our *T. migratorius*, especially in its habits, but the colors in the plumage are very distinct. It is a Mexican species and found in various localities of this region."

3. *Turdus flavirostris* Sw.
" " Proc. Bost. Soc. of N. H., XIV, p. 276.

Mazatlan, Tres Marias, Grayson; Plains of Colima, Xantus.

"Is also abundant on the Marias as well as the main-land, and may be found in either locality throughout the year. It is an inhabitant of the woods, gregarious and semi-migratorius; passing from one part of the country to another in quest of the different kinds of berries, which are its chief subsistence. The resemblance between this and our common robin of the Atlantic States is quite appreciable."

This species appears to be peculiar to western Mexico. It seems to be rare in European collections, as Messrs. Sclater and Salvin state (P. Z. S., 1870, p. 550) that a specimen from Mexico submitted to them by Mr. Boucard, was the first to come under their notice in collections from that country. Numerous specimens are in Col. Grayson's collection from the Tres Marias and Mazatlan. It abounds also in the vicinity of Tehuantepec, whence Prof. Sumichrast has sent many very fine examples.

4. *Melanotis cærulescens* (Sw.).
" " Proc. Bost. Soc. of N. H., XIV., p. 275.

Mazatlan, Tepic, Tres Marias, Grayson; Plains of Colima, Xantus.

"Very abundant in the Islands of the Marias, and one of the most interesting songsters of that locality, where it is very docile, inhabiting the thick woods. Upon the main-land, in the vicinity of Mazatlan, it is not so common, and is very shy."

5. *Harporhynchus curvirostris* (Sw.).
Tepic, Grayson; Mazatlan, Xantus, Bischoff.

"A common resident in this locality and the high central plains to the city of Mexico."

6. *Harporhynchus graysoni* Baird.
" " Proc. Bost. Soc. of N. H., XIV., p. 298.
Island of Socorro, Grayson.

"Like all birds of the genus, this is a charming songster; I found it to be quite tame, seeming to be fond of our company, and while in the lonely solitudes of its home we were cheered both by night and by day with its sweet melody."

7. *Mimus polyglottus* (Linn.).
" " Proc. Bost. Soc. of N. H., XIV., p. 277.
Mazatlan, Grayson, Bischoff; Tres Marias, Grayson.

"Not common in the Tres Marias, but resident there. It is identical with specimens from the main-land, whence it doubtless found its way to the islands."

Fam. SAXICOLIDÆ.

8. *Sialia mexicana* Sw.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 329.
Mazatlan, Grayson; Plains of Colima, Xantus.

Fam. SYLVIIDÆ.

9. *Polioptila cærulea* (Linn.).
Mazatlan, Bischoff; Tonila, Xantus.

10. *Polioptila nigriceps* Baird.
Mazatlan, Tepic, Grayson.

"Found in the low brushy woods at all seasons."

Fam. TROGLODYTIDÆ.

11. *Rhodinocichla rosea* (Less.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 329.
Mazatlan, Grayson; Sierra Madre, Xantus.

"I have not been able to discover this bird in any other locality than the thickly wooded district bordering the Rio Mazatlan; here it seems to remain throughout the year, concealing itself in the densest brush, where its voluptuous and melodious notes are often heard when the bird would be invisible."

The proper family affinity of this remarkable species is not yet definitely settled. Dr. Finsch, l. c., has it under Dendrocolaptidæ, and Mr. Gray in his "Hand List of Birds" places it among the Turdidæ. Col. Grayson states that its habits are very similar to those of the Thrushes. Possibly it should occupy an independent position between the Thrushes and Wrens; its great vocal powers would seem to exclude it from Dendrocolaptidæ.

12. *Campylorhynchus humilis* Scl.
Mazatlan, Bell; Colima, Xantus.

13. *Catherpes mexicanus* (Sw.).
Tepic, Guadalajara, Grayson.

"Usually met with in the interior, inhabiting the ruins and houses of towns and cities. Not found at Mazatlan or in any part of the coast region."

14. *Thryothorus felix* Scl.
" " Proc. Bost. Soc. of N. H., XIV, p. 278.
Mazatlan, Tres Marias, Grayson.

"The woods of the Tres Marias Islands are well supplied with songsters, in which the ever cheerful and happy song of the wren is often heard to mingle at all hours of the day. Like nearly all the birds of these islands, it is very docile, almost suffering itself to be trodden upon, when it is busily occupied in searching among the dry leaves on the ground for its insect prey, indeed most of the specimens procured I killed with a long switch, as I did the Hummers. It seemed to be constantly occupied in searching for insects, occasionally mounting some low branch, often two together, each vying with the other in their melodious rapture, for a few moments at a time, when they would again resume their vocation."

15. *Thryothorus sinaloa* Baird.
Mazatlan, Sinaloa, Grayson; Colima, Xantus.

"This little wren is common from Sinoloa to Tehuantepec. Its nest is generally built in the drooping branches of a thorn tree, thus giving the abode of the young some protection against the innumerable ants and other insects that would otherwise infest it. Most of its congeners build their nests in hollow logs, among roots of trees, etc. The nest is partly suspended from the branches and built of fine grass. The eggs are usually five in number, and marked with small specks of a brownish color."

16. *Thryothorus bewickii*, var. *leucogaster* Gould.
Guadalajara, Grayson.

"I found this wren along the stone fences and hedges near Guadalajara, but have not seen it near the Pacific coast. It is doubtless a constant resident in many localities in the high central plains."

17. *Troglodytes insularis* Baird.
" " Proc. Bost. Soc. of N. H., XIV, p. 299.
Island of Socorro, Grayson.

"This diminutive species is very abundant and well distributed over the island. As in other members of this family its attire is modest and unpretending, but its song may be heard throughout the day, either among the trees or brush covered rocks that crop out everywhere. I never tired watching them climbing about over old logs, or the trunks of standing trees, creeper like, and often turning up the leaves on the ground at our feet in search of food. In the midst of all this busy occupation for subsistence it frequently stops and mounts a branch or twig to pour forth its cheerful little song, which is of considerable volume for a bird so small."

18. *Cistothorus palustris* var. *paludicola* Baird.
Mazatlan, Grayson.

Fam. MOTACILLIDÆ.

19. *Anthus ludovicianus* (Gm.).
Mazatlan, Grayson.

"Common during winter months."

Fam. Sylvicolidæ.

20. *Seiurus auricapillus* (Linn.).
Mazatlan, Grayson.

"I have met with this species only during the winter months, from November to April. It inhabits the thickest woods, and is very shy and solitary, as well as silent."

21. *Seiurus ludovicianus* (Aud.).
Mazatlan, Grayson; Colima, Xantus.

"This little bird is usually found about stagnant pools, or solitary brooks. It appears to me to be the same species which I years ago noticed about the swamps and river side in Louisiana. It is not common in this locality."

22. *Mniotilta varia* (Linn.).
Mazatlan, Grayson; Colima, Xantus.

"I found this bird in the Sierra Madres in December, and also in the Coast Range in January and April. Not common. Its habits are much like the Nuthatches — inhabiting the older woods."

23. *Parula insularis* Lawr.
" " Proc. Bost. Soc. of N. H., xiv., pp. 278, 300.
Island of Socorro, Tres Marias, Grayson.

"Abundant upon the Tres Marias Islands, and a constant resident; also upon the Island of Socorro, two hundred and fifty miles west-south-west of the Tres Marias. I have never met with it upon the main-land.
"It is remarkable that this bird should be found upon the widely separated islands above stated, and not upon the main-land adjacent to the Marias."

24. *Geothlypis trichas* (Linn.).
Mazatlan, Tepic, Grayson.

"A common species from October until the latter part of June. They migrate to the high central plains to breed. I have seen it in the month of July in the vicinity of Tepic."

25. *Geothlypis poliocephala* Baird.
Mazatlan, Grayson.

26. *Geothlypis philadelphia*, var. *macgillivrayi* (Aud.).
Mazatlan, Grayson.

"I have met with this species in October, December, April and September, but have not seen it during the summer months."

27. *Dendræca auduboni* (Towns.).
Tepic, Grayson; Mazatlan, Bischoff; Tonila, Jalisco, Xantus.

"Common, and widely distributed in the winter months; arrives in December and departs in April."

28. *Dendræca æstiva* (Gm.).
Mazatlan, Grayson; Colima, Xantus.

29. *Dendrœca vieilloti* Cass.
Sylvicola vieilloti Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 329.
Mazatlan, Guadalajara, Grayson.

"A summer visitant, and doubtless comes from Central America, as it is known in Costa Rica, north of which locality Prof. Baird states that it has not previously been recorded. From the month of April until September it is often met with, inhabiting the mangrove evergreens in this locality."

30. *Dendrœca dominica* (Linn.).
Tepic, Grayson; Colima, Coahuyana, Xantus.

"Shot in the vicinity of Tepic in the month of December, 1865, not common, and I believe a winter visitant."

31. *Myiodioctes pusillus* (Wils.).
Guadalajara, Tepic, Grayson; Colima, Xantus.

"Common in some localities during the winter months. I found it near Guadalajara in May."

32. *Basileuterus rufifrons* (Sw.).
Sierra Madre, Grayson.

"Procured in the Sierra Madre in the month of April."

33. *Euthlypis lachrymosa* (Bp.).
Mazatlan, Grayson.

"Unlike the true Flycatchers it does not remain quiet a moment, but is constantly hopping about over old logs, on the ground, in the brush and low branches of trees, its tail spread; whilst thus in search of insects not unlike Granatellus. It is not a common species in this locality, and I have only met with it in the dark woods near Mazatlan River. All the specimens were procured in the winter months."

34. *Setophaga picta* Sw.
Sierra Madre, Grayson.

"This is a beautiful species, and has all the peculiarities in its habits of the Warblers. It is always very busy, actively hopping among the branches in search of insects, at the same time uttering a chirping note. The tail, which is ample and gently graduated, is often spread just enough to show distinctly the broad white tips of the outer feathers, contrasting beautifully with the decided black of the rest of the tail. Not abundant."

35. *Setophaga miniata* Sw.
Sierra Madre, Grayson.

"This is a rare species; I have only seen two or three individuals high up in the mountains. Its habits are like the true Flycatchers, waiting quietly on its perch for passing insects."

36. *Granatellus francescæ* Baird.
" " Proc. Bost. Soc. of N. H., XIV, p. 278.
Tres Marias Islands, Grayson.

"This beautiful little species adorns the woods of the Tres Marias Islands, to which it appears to be peculiar."

37. *Granatellus venustus* Dubus.
Colima, Xantus.

Fam. HIRUNDINIDÆ.

38. *Progne subis* (Linn.).
Guadalajara, Tepic, Grayson.

"I found it breeding in Tepic, in the month of May, also in Guadalajara; they were nesting under the eaves of the houses, or in the water spouts. It is seldom seen in the locality of Mazatlan, and then only accidental and migratory, flying very high."

39. *Hirundo horreorum* Barton.
Guadalajara, Tepic, Grayson.

"Very abundant in Tepic, where they breed in May and June under the roofs of houses, in the corridors; also found in Guadalajara. Only accidental on the seacoast in September and October, apparently migrating."

40. *Tachycineta bicolor* Vieill.
Mazatlan, Grayson.

"Specimen shot in September, not common."

41. *Tachycineta albilinea* Lawr.
Mazatlan, Grayson.

"This handsome little swallow is common at Mazatlan, where it is a constant resident, one among the few swallows that is not migratory. At all seasons of the year its twitter may be heard about the eaves of the tile houses or the spacious corridors of the peculiarly constructed Moorish Mexican haciendas. We often see it skimming along the streets, at times almost touching the pavement in its pursuit of flies. Its customary haunts are near or about large towns or haciendas, and rarely have I seen it far from some human habitation. In April it commences to form its nest, usually beneath the eaves of houses or in holes in the wall, often in the hollow tubes for conveying the water from the flat roofs of the buildings. They are very sociable in their habits, and may often be seen in considerable numbers perched upon the roofs of the houses."

42. *Petrochelidon lunifrons* Say.
Mazatlan, Tepic, Grayson.

"I found this species breeding in the banks of the Mazatlan River in May; it appears to be a summer visitant, as I have not observed it in the winter months."

In Col. Grayson's list of swallows he has the name of "Bank Swallow," but there are no specimens by which to determine the species referred to; it may be either *Cotyle riparia*, *Stelgidopteryx serripennis* or *S. fulvipennis*, neither are there any notes to elucidate the question. *C. riparia* has been obtained at Tehuantepec, by Prof. Sumichrast, but neither of the others.

Fam. VIREONIDÆ.

43. *Ieteria virens* var. *longicauda* Lawr.
" *longicaudata* Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 331.
Mazatlan, Tepic, Grayson.

"Common in brushy localities from October to April."

44. *Vireosylvia flavoviridis* Cassin.
Mazatlan, Grayson; Rosario, Xantus.

"Not a common species in the locality of Mazatlan, usually met with in the mangrove swamps; specimens were shot by me in April and June. I have found them more abundant among the evergreens on Holderness Island. None are seen after August, migrating probably to Central America after breeding."

45. *Vireo solitarius* (Wils.).
Mazatlan, Grayson.

"This species was shot in April near Mazatlan; I have only seen one specimen."

46. *Vireo plumbeus* Coues.
Plains of Colima, Xantus.

47. *Vireo atricapillus* Woodhouse.
Mazatlan, Grayson.

48. *Vireo ochraceus* Salvin.
Mazatlan, Grayson.

49. *Vireo hypochryseus* Scl.
" " Proc. Bost. Soc. of N. H., xiv., p. 281.
Tres Marias Islands, Grayson.

Fam. Laniidæ.

50. *Collurio ludovicianus* var. *excubitoroides* Sw.
Mazatlan, Grayson; Colima, Xantus.

"Common from October to April, probably migrates to the high central plains in summer."

Mr. J. A. Allen (Bull. Mus. Comp. Zool., Cambridge, II., p. 270) considers the "so-called *C. excubitoroides*" not to be specifically distinct from *C. ludovicianus*.

Messrs. Dresser and Sharpe (Proc. Zool. Soc., London, 1870, p. 595) express themselves as being similarly convinced by an examination of "thoroughly typical *L. excubitoroides* and *L. ludovicianus*." They state in addition that: — "In the British Museum, there is a specimen sent to this country by Prof. Baird, under the name of *Lanius elegans*, from Mexico. This bird was kindly shown to us by Mr. G. R. Gray; and we were glad to see it, as it confirms our opinion that the *Lanius elegans* of the American authors is nothing more than *L. ludovicianus*."

I was told by Prof. Baird that the specimen of Lanius sent to the British Museum labelled *L. elegans* must have been so named inadvertently by some of the employés of the Smithsonian Institution, as the only specimen he supposed to be that species, is in the Museum of the Philadelphia Acad. of Sciences. On a re-examination of that specimen, he came to the conclusion that it was a local race of *Collurio ludovicianus*, and in his forthcoming work on the Birds of North America, has described it under the name of *C. robustus*.

Under the species *Lanius lahtora*, Messrs. Dresser and Sharpe, l. c., p. 598, say, "We have the advantage of possessing in this country the type specimen of *Lanius elegans* of Swainson, which is preserved in the national collection. On a close examination this bird

seems to be nothing more or less than *Lanius lahtora*, to which species we have accordingly referred it. Whether the identical specimen described really came from the fur countries as stated, can only be determined by further investigation in the locality whence the type specimen is said to have come; and this question will, doubtless, be set at rest some day by the American ornithologists. It seems possible to us that the shrike in question may have come from some other locality altogether, or it may be a straggler from Northern Siberia into Northwestern America."

Lanius lahtora was first described from the East Indies, but appears to have a wide range, being found to the west in Northern Africa and to the north as far as Siberia. Whether introduced into the United States fauna erroneously or really obtained in the fur countries, is a question of much interest, which may possibly be settled by the investigations now in progress in Alaska, by Messrs. Dall and Elliott.

Fam. Ampelidæ.

51. *Ptilogonis cinereus* Sw.
Sierra Madre near Colima, Xantus.

52. *Myiadestes obscurus* Lafr.
" " Proc. Bost. Soc. of N. H., xiv., p. 277.
Tonila, Jalisco, Xantus; Tres Marias, Grayson.

"The Hilgaro, as the Mexicans call it, is their nightingale; next to the mocking bird it is the favorite caged songster in that land where birds of every hue and song are found, and where the sweetest singers are sought for and caged to enliven the monotonous hours of some fair senorita of 'La casa blanco,' or 'La casa grande.'

"The notes of this bird, when once heard, can never be mistaken for those of any other; they are peculiar and approach nearer to the tunes of a musical box than perhaps do those of any other known species. I have listened for hours to its exceedingly varied notes, both in the woods and when caged, and never became weary of its strange, but melodious song.

"This species inhabits the mountainous regions where the woods are the largest and most dense. I have never met with one in the low lands. At a place called the 'Barranca,' between Tepic and Guadalajara, I found them quite common but very shy. Its food consists mainly of insects and berries, but in cages it is fed upon 'masa', Indian corn made into dough and strongly seasoned with Chili peppers; various kinds of fruit are also given it."

Fam. Tanagridæ.

53. *Euphonia affinis* (Less.).
Mazatlan, Bischoff; Sierra Madre, Xantus.

54. *Pyranga æstiva* var. *cooperi* Ridgeway.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 338.
Mazatlan, Grayson.

"This species makes its appearance here during the winter months. I have seen it late in the spring, but not in the summer. Not common."

55. *Pyranga bidentata* Sw.

" " Proc. Bost. Soc. of N. H., XIV., p. 281.

" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 338.

Tres Marias Islands, Grayson.

"It is quite evident that all the species of birds found inhabiting an island in the ocean, in which they are constant residents or peculiar to the locality, necessarily become more numerous owing to their restricted territory, than those found upon the continent. Nearly all the species that are local to Socorro and the Islands of the Tres Marias, I found to be abundant. This Pyranga is no exception to the rule; it is a common and handsome species, and I have not met with it at any other place than the Marias. Of its further geographical distribution I am not informed; when I discovered it I was strongly impressed that it was an undescribed species, and peculiar to the Tres Marias. Specimens sent to Prof. Baird for determination however, do not make good these facts; I received from him its scientific name, but no further intelligence regarding it."

As is well known, Col. Grayson erred in supposing this species to be peculiar to the Tres Marias. It is given by Sclater from Jalapa and Volcan de Fuego, Guatemala; it is also found abundantly in Costa Rica; none are in Prof. Sumichrast's large collection from Southwestern Mexico.

56. *Pyranga hepatica* Sw.

Sierra Madre, Grayson.

"I discovered this species to be quite frequent in the Sierra Madre Mountains, on their western slope between Mazatlan and Durango in December, but I have never met with it in the *tierras calientes* proper. It seems to be a mountain species."

57. *Saltator plumbiceps* Baird, Ann. Lyc., N. Y., VIII., p. 477.

Mazatlan, Tepic, Grayson; Plains of Colima, Xantus.

"This finch inhabits the forests and breeds in the spring months, during which time it is in fine song; it does not migrate and is a common species in the vicinity of Mazatlan, San Blas and Tepic. The nest is slightly made of small dry twigs and lined with fibrous roots; the eggs are from three to five, of a pale blue color with delicate black hieroglyphic marks on the large end."

There are two specimens in Col. Grayson's collection marked *Saltator francescæ*, as possibly being a distinct species. On examination, I have concluded that they are the young of *S. plumbiceps*, although quite different in color; much the same variation occurs in the adult and young stages of plumage of *Saltator grandis*, the young of which is *S. icterophrys* Lafr.

The two specimens under consideration are olive green above, as are also the wings and edges of the primaries; in one the under plumage and superciliary stripe are yellow; in the other the superciliary stripe and chin are white, the under plumage less yellow, more tawny, and the fore part of the crown plumbeous; this last, therefore, has in part assumed the adult dress of *S. plumbiceps*, in which there are no green or yellow colors.

Fam. FRINGILLIDÆ.

58. *Pheucticus chrysopeplus* (Vig.).

" " Finsch. Abh. nat. Ver. zu Bremen. 1870, p. 339.

Mazatlan, Grayson, Bischoff; Rio de la Ameria, Xantus.

"It is rather common in the vicinity of Mazatlan, where its cheerful and voluminous song is often heard in the woods. It does not migrate."

This species, found only in Western Mexico, has until recently been considered the same as the South American *P. chrysogaster*. Dr. Finsch, l. c., gives a full account of the different stages of plumage of this species, and by comparison with the descriptions and figures given by Lesson, and Jardine and Selby of *P. chrysogaster*, points out their distinguishing characters. He says, — "The Mexican variety is unquestionably that described by Vigors, which cannot be united with *P. chrysogaster* Less., as has hitherto been supposed. Specimens from Peru or Venezuela, which alone can decide that point, are unfortunately not at my command at present."

I have a male specimen of *P. chrysogaster* in perfect plumage, from Ecuador, the difference between which and *P. chrysopeplus* is very striking, especially in regard to size, the yellow coloring of the Mexican bird is much deeper, the sinuated portion of the outer primaries is bordered with white, while in *P. chrysogaster* the ends of the primaries are wholly black, and the quills of the latter are of a deeper black; in the other white markings on the wings, and those of the tail, the two species are much alike; the inner webs of the outer three tail feathers are largely white at their ends in each. In *P. chrysogaster* there is a broad black band across the back, the lores and lower eye-lids are black, the occiput and hind neck are somewhat intermixed with black, and the sides under the wings are sparingly and faintly marked with blackish bars; the back of *P. chrysopeplus* has a few of the feathers marked with black, but the plumage of the lores, the hind neck and under the wings is immaculate.

The two measure as follows: —

P. chrysopeplus. Length (fresh), 10 in.; wing, 5; tail, $4\frac{1}{4}$; tarsus, $1\frac{1}{6}$; bill, high at base, $\frac{3}{4}$; wide at base, $\frac{11}{16}$.

P. chrysogaster. Length (skin), $7\frac{1}{2}$ in.; wing, $4\frac{1}{4}$; tail, $3\frac{1}{2}$; tarsus, $\frac{15}{16}$; bill, high at base, $\frac{11}{16}$; wide at base, $\frac{9}{16}$.

59. *Hedymeles ludovicianus* (Linn.).
Plains of Colima, Xantus.

60. *Hedymeles melanocephalus* (Sw.).
Mazatlan, Grayson; Plains of Colima, Xantus.

"Specimens shot near Rio Mazatlan in February, and near Guadalajara in May."

61. *Cardinalis virginianus* var. *igneus* Baird.
" " Proc. Bost. Soc. of N. H., xiv., p. 281.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 339.
Mazatlan, Tres Marias, Grayson.

The Tres Marias and Mazatlan form proves to be *C. igneus* Baird. I had no specimen at the time of preparing the Tres Marias list, but took the name as given in Col. Grayson's notes.

62. *Cardinalis virginianus* var. *carneus* Less.
Sierra Madre, Xantus.

63. *Pyrrhuloxia sinuata* (Bp.).
Mazatlan, Grayson.

"Specimens shot in February and April, not common."

64. *Guiraca cærulea* (Linn.).
Coccoborus cæruleus Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 339.
Mazatlan, Tepic, Grayson; Plains of Colima, Xantus.

"The Blue Grosbeak appears here from October to April; I procured specimens, however, in the locality of Tepic in the month of June. Tepic is in the *tierra templada*, and the climate is cooler than the Mazatlan region. It is my opinion that the birds migrate to the high central plains of Mexico to breed."

65. *Guiraca parellina* (Licht.).
Manzanilla Bay, Xantus.

66. *Spermophila torqueola* Bp.
" *atriceps* Baird, Ann. Lyc. N. Y., VIII., p. 479.
Mazatlan, Grayson, Xantus; Plains of Colima, Creston, Xantus; Tepic, Grayson.

"Our present bird, though diminutive in size and of a subdued, modest and becoming dress, possesses those qualities of cheerfulness and a delicately sweet little song, which always render it attractive and interesting. They are constant residents in the State of Sinaloa, near the coast, and in the vicinity of Tepic they are quite numerous. I also saw them in Tehuantepec.

"They do not associate in flocks, but often in pairs, sometimes a few may be seen in the same locality. I always found them inhabiting the openings, in which there is an abundance of low bushes, weeds and grass, the small seeds furnishing their principal means of subsistence.

"In the months of April, May and June the males are in full song. The nest is placed in a low bush, and compactly formed of fine roots, with but little lining; the eggs, five in number, are nearly white or very pale blue. Two broods are raised in a season and perhaps more, as I have found young birds just able to fly in October."

Mr. Sclater (Ibis, 1871, p. 6) decides that *S. atriceps* Baird, is *S. torqueola* Bp., in immature plumage.

67. *Volatinia jacarina* (Linn.).
Mazatlan, Grayson; Mazatlan River, Mts. of Colima, Xantus.

"Common from the latter part of June to September, inhabits clearings with low brushwood and rank weeds; the male, during the breeding season, may be seen making frequent short flights or jumps from its perch on the top of a weed or bush, always returning to the same spot."

68. *Cyanospiza ciris* (Linn.).
Mazatlan, Grayson; Plains of Colima, Xantus.

"A winter visitant to this locality; specimens shot in February."

69. *Cyanospiza amœna* (Say).
Mazatlan, Grayson.

70. *Cyanospiza versicolor* (Bp.).
Mazatlan, Grayson.

"This beautiful little finch is quite a common species about the vicinity of Mazatlan, where it is a constant resident; I also found it at Tepic in the State of Jalisco. It appears to represent, on the Pacific slope, its more brilliantly plumaged ally of the Southern Atlantic States, the Nonpareil (*C. ciris*), which is only a winter visitor to this region. It has a sweet little song, which it often warbles in the morning and evening from the top of some bush or weed in hearing of its modestly attired mate. The plumage of the adult male is very pretty, the rich reddish-purple predominating upon the upper and lower parts, whilst the rump is con-

specuous with a lustrous purplish-blue or lilac. The female, on the contrary, wears a plain brown dress, and were it not for her gorgeously attired spouse, would scarcely be recognized from some common little brown sparrow."

71. *Cyanospiza leclancheri* (Lafr.).
Sierra Madre, Rio de la Ameria, Xantus.

72. *Euspiza americana* (Gm.).
Mazatlan, Grayson.

"This handsome wood sparrow is not common in this locality; only two specimens have been procured, male and female, which were shot in the month of August by my friend Mr. Brewington. They were found in the woods near Mazatlan, and appear to be arboreal in their habits."

73. *Zonotrichia leucophrys* var. *gambelii* (Nutt.)
Mazatlan, Grayson.

74. *Aimophila melanotis* Lawr.
Plains of Colima, Xantus.

75. *Melospiza lincolni* (Aud.).
Mazatlan, Grayson.

"Very common in the coast region in the winter months, and in the locality of Tepic at all seasons.

76. *Peucea æstivalis* var. *botteri* Sel.
Coturniculus mexicanus Lawr., Ann. Lyc. N. Y., VIII., p. 474.
Plains of Colima, Xantus.

77. *Coturniculus passerinus* (Wils.).
Mazatlan, Grayson.

"A winter visitant; not abundant."

78. *Embernagra chlorura* (Aud.).
Mazatlan, Grayson.

"A winter visitant, specimens shot from December to April, numerous in some localities. Its notes have a faint resemblance to those of the Towee finch; it passes much of its time among the weeds in old fields and in brushy places, feeding upon various kinds of seeds; I have seen it feeding upon the seeds of the silk cotton."

79. *Pipilo fuscus* var. *crissalis* Vigors.
Guadalajara, Grayson.

"This species I found quite abundant about Tepic, and in many places on the road to Guadalajara on the high central plains. I have not met with it nearer the sea-coast than Tepic, where it appears to be a constant resident."

80. *Pipilo erythropthalmus* var. *carmani* Lawr.
" " " Ann. Lyc. N. Y., x., p. 7.
" " " Proc. Bost. Soc. of N. H., XIV., p. 299.

Island of Socorro, Grayson.

"I found this finch to be very abundant upon the Island and remarkably tame. It was by observing the habits of this bird that water — a small spring percolating beneath the boulders and loose rocks near the

tidal mark — was discovered; but for this incident we might have suffered greatly, long before the necessary article could have been found by us, as any one would have taken it to be sea-water which flows and ebbs to it, had we not seen our little friend in the act of drinking. No other water was discovered, although it doubtless exists in other places on the Island."

81. *Pyrgisoma rubricatum* Cab.
" *xantusii* Baird, Ann. Lyc. N. Y., VIII., p. 480.
Mazatlan, Grayson, Xantus; Plains of Colima, Xantus.

"Not an abundant species, although not an uncommon one in this locality. Inhabits chiefly the woods; resident all the year. I found it also in Tepic and San Blas regions."

82. *Chondestes grammaca* (Say).
Mazatlan, Grayson; Plains of Colima, Xantus.

"Arrives in September and departs in April; common."

83. *Carpodacus frontalis* (Say).
Guadalajara, Grayson.

"I found this species in the city of Durango in February, in Guadalajara in May, and in Tepic in December, May and June. It breeds in these localities; it does not visit the coast region."

84. *Chrysomitris psaltria* var. *mexicana* Sw.
" " " Proc. Bost. Soc. of N. H., XIV, p. 282.
Tres Marias Islands, Grayson.

Fam. ALAUDIDÆ.

85. *Otocoris alpestris* var. *chrysolæma* (Wagl.).
" " " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 341.
Mazatlan, Grayson.

Fam. ICTERIDÆ.

86. *Cassiculus melanicterus* (Bp.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 363.
Mazatlan, Grayson, Bischoff; Tepic, Grayson; Plains of Colima, Rio de Coahuana, Xantus.

"An abundant and common species and a constant resident; it is well distributed throughout the woods of the *tierra caliente*. They associate in flocks of from ten to thirty. Their long pensile nests are sometimes three or four feet in length. I found it equally abundant in Tehuantepec, but none in the Tres Marias Islands.

"It does not migrate except from one part of the forest to another. The Long-tailed Jay (*Colacitta colliei*) frequently accompanies them in their perambulations through the woods in quest of their insect prey, or various kinds of fruit upon which they subsist.

"Among the many curious objects which meet the eye of the traveller in the tropical regions of Western Mexico, are the long pendant nests he sees swaying in the breeze, attached to a small twig and frequently overhanging the path he is travelling. These are the nests of the Double-crested Oriole. Beneath the wide-spreading branches of the mimosa, acacia, higuero, or any large tree that affords an ample shade, may often be seen as many as half a dozen of these firmly woven structures, suspended in the air and moved by the slightest breeze. The material of which they are composed is generally a very long, coarse and tough grass,

selected with great care as to its elasticity and strength; sometimes narrow strips of the palm-leaf, and again I have seen some that were constructed of a slender and pliant kind of creeper, and, near the villages, twine and thread are sometimes mixed with grass. Any long and slender substance of a tough nature is selected by this ingenious weaver, to make secure its domicil against the storms of the Tropics. They are often a yard in length, with the entrance near the top, which is rather small and nearly closed when the bird is inside, and at the bottom of her pocket-shaped nest. A truly wonderful ingenuity is exhibited in the mechanism of these bird 'homes.' Apparently they seem to be loosely put together, admitting the air to pass freely through them, not unlike a net hammock; but any attempt to pull one of them apart, or detach it from the twig to which it is bound, is not easily accomplished without the aid of a knife.

"The building of this structure is performed by the female alone; the male only keeping watch whilst she is engaged inside, or accompanying her in searching for building material. The eggs of this species, usually five in number, are longer in shape than those of the other members of the Oriole family; their markings, however, are similar, the ground color being a pale blue, with numerous brownish-black spots and zigzag marks, some of which resemble letters and hieroglyphics written with a bad pen."

87. *Icterus spurius* var. *affinis* Lawr.

Mazatlan, Grayson; Plains of Colima, Xantus.

"Appears to be a winter visitant to this locality, although I procured both male and female in the latter part of August, 1865, possibly the early comers. It is not very common at any season."

88. *Icterus cucullatus* (Sw.).

Mazatlan, Grayson; Plains of Colima, Xantus.

"I have noticed but two examples of this species, both of which I procured, shot from the same tree; they were feeding upon the fruit of the wild fig (*Ficus americanus*), in company with other orioles (*I. pustulatus*). They are rare in this locality and new to me."

89. *Icterus wagleri* Sel.

" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 338.

Tepic, Guadalajara, Grayson.

"In the large and beautiful garden and orchard attached to the spinning factory of Barron and Forbes in Tepic, I first met with this rare and pretty species. This lovely retreat is called Jauja, and is indeed just what its name implies, a garden of Paradise. It is situated on the banks of a clear running stream, that propels the machinery of the factory, a large enclosure to itself, with the limpid waters sweeping around more than one-half its length.

"Everything that art and taste could suggest has here been exhibited in the admirable distribution of nearly every kind of tropical fruit trees, as well as some of the northern ones; orange groves and mango, with their dark evergreen foliage, forming the most delightful and shady bowers, perfumed with the fragrance of innumerable native as well as exotic flowers, plantains, coffee,—really a wilderness of plants, kept in elegant order, among which gravelly walks lead in every direction; all of which appears as an oasis amid the thorny and scrubby brush peculiar to the surrounding country. A fit spot to attract the various species of birds for many miles around.

"In Jauja, where everything is conducted in a quiet and systematic manner, birds are never molested, but seem to form a part of the richly ornamented grounds in which they love to dwell; and in this genial clime, where frost and snows are unknown, they have no desire to leave it. Here they rear their young, and their voices are heard in their varied songs, every month in the year. My first visit to this spot was in the month of May (the commencement of the breeding season), when all the birds were in their finest song and feather. Such a busy scene, and such a medley of song, I have seldom witnessed. It seemed as though all the vocalists of the forest and field had collected here for a grand concert, a kind of national congress of musicians or May-day festival, each endeavoring to outvie his neighbor.

"This was the only locality in the vicinity of Tepic in which I found this oriole. I saw them feeding upon the ripe coffee berries, and probing the ripest oranges with their sharp bills and sucking the juice. There

were only a few of them, and I believe they seldom left the garden. Subsequently I procured specimens in a garden near Guadalajara, and saw some in cages in the City of Mexico. I have never met with it in the forest of the Western Coast region, and consider it comparatively rather a rare species in Western Mexico."

90. *Icterus pustulatus* (Wagl.).

Tepic, Grayson; Mazatlan, Xantus, Bischoff; Plains of Colima, Manzanilla Bay, Xantus.

"Of the numerous species of orioles inhabiting the Tropics, this one is the most familiar about the locality of Mazatlan, and indeed all of Western Mexico. I found it as far south as Tehuantepec, Guadalajara, Tepic, and other places, where I always met with it as a well-known and common species. Its long pensile nest, its sprightly little song, and more especially the gay plumage of a fully adult male, renders it a conspicuous bird among the feathered songsters of its native woods.

"The nests are generally suspended from a tough, slender branch or recumbent twig of the acacia tree, protected from the intense rays of the sun by the beautiful canopy of its fringed foliaged branches. Such a tree as the tamarind acacia is often selected, and one or two nests are sometimes seen swaying in the breeze, beneath the generous shade of this perennial beauty of the forest. The nest is composed of the thread-like or elastic fibres of the maguey plant. I have seen some in which cotton thread and twine were component parts of its elastic and firm structure. The nests are of various lengths, conformable to the materials at hand for the intricate formation of the warp necessary for the weaving of this unique and airy abode, in which to rear their little family. The inside bottom is lined with the downy substance of the tree cotton, intermixed with a few feathers. In one nest I found an entire skein of yellow silk, which it had doubtless picked up where some village brunette had dropped it.

"The eggs are generally five in number, rather long, of a pale blue ground, with numerous hieroglyphic scratches confluent around the larger end."

91. *Icterus grayson*i Cass.

" " Proc. Bost. Soc. of N. H., XIV, p. 280.

" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 336.

Tres Marias Islands, Grayson.

"This fine species I found to be quite abundant upon the Three Marias, where it appears to be local and peculiar."

92. *Molothrus pecoris* var. *obscurus* (Gm.).

Mazatlan, Grayson; Manzanilla Bay, Xantus.

"The remarkable and apparently unnatural habits of this species, in preparing no nest in which to rear their young, but selecting those of other birds, distributing an egg in each, leaving it to be hatched and the nestling to be reared by foster parents, is well known to ornithologists, as well as to the scrutinizing observer of nature, whose wonders are revealed to him in many strange forms.

"The birds whose nests are selected in which to deposit its egg are usually smaller than itself. In the vicinity of Mazatlan, the beautiful and basket-shaped nest of *Vireosylvia flavoviridis* seems to be the one preferred. This Vireo is a summer visitant from the regions of Central America; soon after their arrival they commence their nidification, which is in May and the early part of June. The nest is generally placed pendant between two branches, usually low down. I have found this species quite abundant on a small, thickly wooded peninsula near the sea-shore, but a short distance from the city of Mazatlan. Here I have seen the female Cow-bird stealthily seeking an opportunity to drop its egg in the nest of the Vireo. She at length finds this opportunity in the absence of the true owners of the nest, but not before one egg at least has been laid does she deposit hers by its side, otherwise the Vireo would abandon it. The intruder's egg is first hatched, and the others a little after. The larger size and greater strength of the foundling absorbs all the attention of the poor dupe of a dame, and she proves a very affectionate and assiduous nurse to the uncouth stranger.

"The Cow-bird is very numerous in the region of Mazatlan and Tepic, and in fact pretty generally distributed over Mexico. About Mazatlan they are seen in large flocks, often in company with the larger species of this genus, *M. æneus*."

93. *Molothrus æneus* (Wagl.).
Mazatlan, Grayson; Manzanilla Bay, Mts. of Colima, Xantus.

"We now come to a larger species of Molothrus or Cow-bird, whose habits, though less known than the preceding smaller species, are, however, very similar so far as my own observation is concerned. That this species also deposits its eggs in the nests of other birds, I have not the least doubt; indeed, I am fully convinced from the facts which have presented themselves to me when I have been assiduously watching their movements during the breeding season.

"On the 19th of May, 1868, whilst hunting in the woods near Mazatlan, I discovered a nest of the Bull-head Fly-catcher (*Pitangus derbianus*), which is a common species in this region, and builds a large nest, dome-shaped, the entrance being on the side. Whilst I was quietly looking at the nest (which was about forty feet from the ground), I observed a female Red-eyed Cow-bird among the branches of the same tree looking very melancholy. Suddenly she darted towards the nest, upon the side of which she perched, and immediately attempted to enter, but the vigilance of the fly-catcher was too acute, and observing the intrusion upon her sacred domicil, quickly attacked the Cow-bird and drove her instantly away. I soon after saw the same bird examining the nest of the Mazatlan Oriole (*Icterus pustulatus*), but as there had been no egg yet laid in the nest, it did not seem to suit her, and she soon disappeared in the intricacies of the forests, leaving me strongly impressed as to her intentions.

"The exceedingly thorny nature of the woods in this country renders the close observation of the nests of birds very difficult, almost impracticable.

"The Red-eyed Cow-bird is a very common species in North-western Mexico; it may be seen frequenting the villages and towns in flocks, associating with the Grackles and smaller Cow-birds. They are generally distributed throughout Mexico. I shot a young male in San Blas which had attracted my attention by its having what I supposed a snow-white crest, but on being examined it proved to be a piece of white cloth stitched in the scalp, and trimmed to represent the comb of a cock; it had doubtless been done when the bird was very young by some of the natives, as the wounds of the operation were entirely healed."

94. *Agelaius phœniceus* (Linn.).
Mazatlan, Grayson.

95. *Agelaius gubernator* (Wagl.).
Mazatlan, Tepic, Grayson.

"Abundant in the vicinity of Tepic, inhabiting the fresh water marshes, also in similar localities near Mazatlan; resident."

96. *Xanthocephalus icterocephalus* (Bp.).
Mazatlan, Grayson.

97. *Sturnella magna* var. *neglecta* (Aud.).
Mazatlan, Grayson.

"A constant resident from Mazatlan to the high central plains near Guadalajara."

98. *Scolecophagus cyanocephalus* (Wagl.).
Mazatlan, Grayson.

99. *Quiscalus major* Vieill.
Manzanilla Bay, Plains of Colima, Xantus.

100. *Quiscalus major* var. *macrourus* Sw.
Guadalajara, Grayson.

"I procured specimens of this large species only in the vicinity of Guadalajara, and I thought I saw it in San Blas on the sea coast. I have not met with it in the locality of Mazatlan."

101. *Quiscalus major* var. *palustris* (Sw.).
Mazatlan, Grayson.

"I was not aware until I saw Mr. Cassin's description (Proc. Acad. Nat. Sci., Phil., 1866, p. 411) that two species existed in the Mazatlan region. I always supposed those with brownish thighs (*Q. palustris*) to be young birds in immature plumage. I have examined a good many, and all with brown thighs appeared to me to be young birds of the year, and the adult birds answering to the description of *Q. tenuirostris*, having the thighs blue-black like the rest of the under parts, without a shade of brown. Mr. Cassin, however, is doubtless correct, and Mr. Swainson's discovery of the same bird in the valley of Mexico, and describing it as a distinct species, is a strong support to Mr. Cassin's conclusion. I shall endeavor, however, to throw as much light as possible upon the subject, by a more careful observation in future, in order that the facts may be entirely set at rest in my mind.

"It is a 'close shave' in determining some of these nearly allied species. *Q. major* and our present bird, *Q. palustris*, are very much alike, as well as *Q. tenuirostris*, all inhabiting the lower countries. A still larger Boat-tailed Grackle (*Q. macrourus* Sw.) is quite common near Guadalajara, living most of the time in the irrigated gardens and orchards, where I found them breeding among the orange trees.

"*Q. palustris* is very common in the coast region of Mazatlan, where it is seen in flocks frequenting the marshes on the Esteros, in search of small crabs and water insects. Many of them, however, take up their abode in the towns and villages, and become very docile; they are there attracted by the grains of waste maize, and the refuse crumbs and meats thrown from the dwellings. In the town of San Blas they are so numerous and domestic as to be a nuisance, often entering the houses and carrying off whatever kind of provision they can find, meat as well as grain. At the hotel where I was stopping in that town, it was necessary to keep a servant watching the table, whilst the meals were being prepared, to keep them from demolishing the tortillas and beans. In the city of Mazatlan, about twenty congregate in front of my window to receive their daily bread, a few crumbs of which I throw to them every morning.

"They always build their nests in communities, selecting a grove of ordinary sized trees, usually near some fresh water lagoon, and sometimes in the trees that ornament the dwellings of the natives. The nests are placed in the topmost branches, and are composed of coarse grass and roots externally, and plastered inside with cow-dung or mud. The eggs are usually five, of a pale blue color, with numerous zigzag marks of black."

Probably Col. Grayson's first conclusion was right in considering the birds found at Mazatlan with blue thighs and with brown ones, as different ages of the same species, viz., *Q. palustris*. Unfortunately the promised further investigation was prevented by his premature death. It is therefore desirable that specimens of the *Quiscalus* with blue-black thighs, from the vicinity of Mazatlan, should be examined, that its true position may be ascertained; three male specimens of *Q. palustris* in the collection have their thighs dark brown.

Col. Grayson erroneously quotes Mr. Cassin as stating that *Q. tenuirostris* has the thighs blue-black, and as being found at Mazatlan. Mr. Cassin gives no special locality, only "from Mexico," and does not give the color of the tibia. However, Swainson says, "inhabits the marshes adjoining Mexico." And on an examination of *Q. tenuirostris* in the Philadelphia Academy, I found the thighs to be of an ochreous brown, much lighter than those of *Q. palustris*, which are of a very dark brown; its occurrence at Mazatlan, perhaps, may be considered to be doubtful.

The brown thighs, therefore, will not answer as a distinguishing character for *Q. palustris*, the fact of *Q. tenuirostris* also having them brown, seems to have escaped the observation of Mr. Cassin.

Mr. Cassin has strangely erred in giving the feet of *Q. tenuirostris* as black, instead of which the tarsi and toes are of a clear brownish-red, and the claws brown; the tarsi, toes and claws of *Q. palustris* are black, but these Mr. Cassin has not noticed.

I have no doubt that the two species are rightly determined by Mr. Cassin, for in general coloration and in form they are as described by Mr. Swainson and by himself. The bill of *Q. palustris* is shorter, and very much wider at the base than in *Q. tenuirostris*, the latter species is somewhat larger in all its measurements.

Fam. Corvidæ.

102. *Corvus corax* var. *carnivorus* Bartram.
Mazatlan, Grayson.

"Not common, but occasionally met with at any season."

103. *Corvus mexicanus* Schl.
Mazatlan, Grayson, Xantus.

"So far as I am acquainted with this species it appears to be confined in its geographical distribution to the northwestern parts of Mexico, bordering the sea coast. In Tehuantepec I did not see it, nor have I met with it anywhere in the interior far from the sea. It is quite common at San Blas and Santiago River, and I am inclined to believe that its geographical range rests principally within the limits of these regions.

"It breeds in San Blas, forming its nest in the tall cocoanut palms that grow in the town, and I also found some breeding similarly in the suburbs of Mazatlan; but it is more numerous on the Mazatlan River; there I discovered its nest in the thorny mimosa trees. The nest is composed of small sticks and grass, much like that of the common crow; the eggs too are much like those of that species, but smaller.

"This is the smallest crow yet discovered upon our Continent, and is decidedly the handsomest. It is impossible to convey to the reader, either by pen or pencil, the glossy satin-like appearance of its plumage; in some lights exhibiting the most delicate and beautiful shades of purple, violet and bronzy reflections, so smooth, compact and soft is it, that the light trembles and scintillates from its surface as from polished steel. Its form is compact, and its general appearance much like the common crow, as well as its habits, though the present species is a little more arborial, feeding upon the various kinds of fruit which it finds in the trees of the tropical forests. Like the common crow, however, it often descends to the ground in search of insects and their larva, which it hunts for by turning up bits of wood, and in the newly ploughed fields; but it may be more frequently seen upon the seashore at low tide, near the mouth of the Esteros, searching for the small crabs, snails and other shell-fish that abound in such localities.

"In the fall and winter months they congregate in large flocks, visiting the fields of Indian corn first ripened, in which they do considerable damage; but unlike the American crow, he is not persecuted to death for this bit of roguery. The natives seldom molest them. They sometimes visit the sand bars of the river in large flocks, for the purpose of bathing. The voice of this crow is something like that of the common species, but less harsh, indeed some of its notes are quite musical."

104. *Cyanocitta beecheyi* (Vig.).
Cyanocorax beecheyi Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 333.
Mazatlan, Grayson, Bischoff; Tres Marias, Xantus.

"This, I believe, is the largest of the true jays, nearly as large as the small crow found in the same locality, and which the male very much resembles about the head. The colors are very rich and decided, all the under parts, head and neck, of a jetty-black, the back, wings and tail being of a beautiful blue, with a purplish wash; the bill of the female is yellow, that of the male black; the feet of both being yellow, armed with sharp strong claws, nearly as powerful in their grip as those of some small hawks; no difference in the colors of the male and female, except in the bill and eyes.

"There is nothing it will not pilfer and carry off, if able to do so, when it visits the huts and ranchos of the natives, and hen's eggs he is particularly fond of; he never fails to rob every bird's nest of its eggs, provided the parents are not successful in driving him off, but in these thieving exploits he is very shy and quiet, generally succeeding in evading the weaker parent birds, who do all in their power to drive the heartless invader away from their dear treasures.

"The geographical distribution of this jay is less extensive than the Urraca (*C. collici*); I did not meet with it in Tehuantepec, and I think it more abundant in Sinaloa, or Northwestern Mexico than it is farther south. I have generally met with it among the low scrubby forests of the poorer lands of Sinaloa, to which it seems to be more partial than the rank woods in some parts of the country. Its food consists of grubs, beetles, and various kinds of insects; also many kinds of fruit; it is also very fond of meat; corn when to be had he is very partial to, and holding the grain between his claws, he divides it with great dexterity by hammering it with his strong bill. Iris of the male yellow, that of the female gray."

In Xantus' collection I find specimens of this species obtained on the Tres Marias Islands, which I was not aware of when I gave a list of the birds found there.

105. *Cissolopha sanblasianus* (Lafr.).
Plains of Colima, Manzanilla Bay, Los Trochas, Xantus.

106. *Calocitta collici* (Vig.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 334.
" *elegans* " " " " " p. 335.
Mazatlan, Grayson, Xantus, Bischoff.

"All the Jay family are more or less addicted to mimicry, gesticulation, and a great propensity to thieving, robbing every bird's nest of its eggs, or even its young, if not driven off by the owner. The Urraca is an adept in all these accomplishments, if not superior to his congeners in cunning and intelligence.

"After the month of September the Urracas in families of seven or eight will almost invariably be found in company with the small flocks of Double-crested Orioles (*Cassiculus melanicterus*), with whom they continue all the winter until the breeding season arrives. They follow the orioles through all their perigrinations in the woods, in order to share a part of the various beetles, grasshoppers and other insects, and their larvæ which the more active orioles are better fitted to uncover from their hiding places in the bark and leaves of trees. They thus pass the time hunting amicably together, the orioles seeming to be satisfied with their society, and at the same time the ever vigilant Urracas, being on the alert, give timely warning of danger.

"The Urraca Jay builds its nest in May; it is composed of rough thorny sticks, and lined with moss or fibres of roots and grass; it is about as large as that of a magpie, and like that bird, a great deal of caution is observed in locating it in some inaccessible thorny tree.

"Of the numerous species of jays, the Urraca excels all in size and showy appearance, his elegant form, his splendid plumage of glossy blue upon the upper parts, whilst his under dress is a pure white; his very long and graduated tail, the two central feathers of which in some individuals measure two feet; the ample recurved crest of black feathers tipped with blue, surmounting a well-shaped head, the jetty plumage of his neck and throat, forming a crescent upon his white breast, like an escutcheon — all of which gives to our hero a truly regal and princely air, beautifully harmonizing with the tropical forest in which he lives.

"It is a habitant of Western Mexico, generally met with in the thick and voluptuous forest of the *tierra caliente*, near the Pacific coast. It is seldom seen to the eastward of the summit of the Cordilleras. Its geographical range being from Sinaloa, Mexico, to Central America; in all this region it is common, though an interesting bird to the traveller or native, and generally elicits a full share of admiration as he appears conspicuous among the numerous gaudy tenants of his native woods. Often have I paused upon the road to watch his eccentricities, his dodges, his taunts and jeers, of which he is unsparing to the stranger. They will then follow the traveller for half a mile or more, until their curiosity seems to be satisfied, when suddenly, with the greatest seeming contempt, they will fly off with their wings and tail spread to their fullest extent, uttering a loud squally note, seeming to say — Adios Gringo!

"The adult has the crest of the head black, the feathers forming it often tipped with blue, and sometimes entirely black. A young male now before me has all the feathers forming the crest distinctly tipped with white. In the young or immature birds the black of the chin and throat is replaced by a dirty white, with a mixture of black, edged with a black crescent-shaped band dividing it from the pure white of the rest of the under parts.

"There is no perceptible difference in the sexes."

In the different collections there are seventeen specimens, all purporting to be this species; nine of them are fully adult; in these the long central crest feathers are black, with their ends just tinged with blue; six of the others have the crest feathers ending with white; one of these specimens is younger, it has the chin black, the throat bluish-white, surrounded with black; this seems to be the stage of plumage on which Dr. Finsch, *l. c.*, founded his new species, *C. elegans*. The other two are nearly adult, and in fine plumage, the ends of the crest feathers blue, just tipped with bluish-white. It appears therefore that the long crest feathers are tipped with white in the younger birds, and that this color is gradually replaced by blue in the adult. The markings, also, on the ends of the shorter crest feathers differ in the various specimens, showing a transition from white to blue. There appears to be some irregularity in acquiring the fully mature plumage; in some the throat is entirely black, while the crest feathers are still tipped with white; in others the white has entirely disappeared from the crest feathers, and the throat feathers have their ends bluish-white, retaining on that part the plumage of the immature bird.

Mr. Salvin suggests that the difference of plumage between *C. colliei* and the *C. elegans* of Dr. Finsch, may be sexual. But, as stated by Col. Grayson, the sexes do not differ in plumage; this is also shown by the examples, there being old and young of both sexes in which the plumage is the same.

I much fear that the species of my friend Dr. Finsch cannot be sustained, and had he the same evidence before him that I have, he would doubtless come to the same conclusion.

107. *Calocitta formosa* (Sw.).
Manzanilla Bay, Rio de la Ameria, Xantus.

108. *Xanthoura luxuosa* (Less.).
Sierra Madre, Xantus.

Fam. Dendrocolaptidæ.

109. *Dendrornis mentalis* Baird.
" " Ann. Lyc., N. Y., viii., p. 481.
Mazatlan, Grayson, Xantus, Bischoff; Tepic, Xantus.

Fam. Tyrannidæ.

110. *Attila cinnamomeus* Lawr.
" " Ann. Lyc., N. Y., x., p. 8.
Mazatlan, Grayson.

"Not a common species, found in this locality the entire year, inhabits the thick woods; I also found it in the State of Jalisco, near Tepic. It feeds upon the various kinds of wasps and bees; the stout and numerous rictal bristles are well arranged to protect it from their sting. The singular form of the bill is a distinguishing feature in this species; it has the appearance of being slightly curved upwards to near the tip, which is bent downwards in a very acute point, the culmen very prominent, the under mandible curved upwards, commissure nearly straight, bill notched at point."

111. *Sayornis nigricans* (Sw.).
Mazatlan, Grayson.

112. *Camptostoma imberbe* Scl.
Mazatlan, San Blas, Grayson.

"Shot near San Blas, in the latter part of June; found in the vicinity of Mazatlan. Not common, but appears to be resident."

113. *Elainea placens* Scl.
" " Proc. Bost. Soc. of N. H., XIV, p. 279.
Tres Marias Islands, Grayson.

"Resident in all localities of the Tres Marias Islands."

114. *Myiozetetes texensis* (Giraud).
Mazatlan, Grayson, Xantus; Tepic, Grayson; Plains of Colima, Tonila, Xantus.

"Like the Bull-headed Flycatcher (*Pitangus derbianus*), this also builds a dome-shaped nest, and very large for the size of the bird. The nest is composed of materials similar to the larger kind. It is a little singular that of the numerous flycatchers, these are the only known species that construct their nests in this peculiar form.

"The Red-crowned Flycatcher is not an uncommon species in the region of Mazatlan, where it may be met with in the sparsely wooded districts, in which there are scattering large trees and stunted thorny underwood, near some fresh water stream or lagoon.

"The notes are shrill and clear, with but little variation, and when uttering them it has a peculiar manner of stretching its neck and casting its head from side to side, whilst its tail is in active motion. The males have frequent combats during the love or breeding season, and they sometimes fall to the ground clinched together in these furious paroxysms of rage; jealousy seems to be the prime cause of these assault and battery cases, and the victor is rewarded by winning the object of contention. Although it builds its nest in the same tree with other birds, yet it will not be on such intimate terms with its own species. It sits upon its perch waiting for the passing winged insects of its choice, which it pursues with a rapid flight, the wings making a rustling noise, when in the act of darting on its prey."

115. *Pitangus derbianus* (Kaup.).
Saurophagus derbianus Finsch, Abh. nat. Ver. zu. Bremen, 1870, p. 329.
Mazatlan, Grayson, Bischoff; Plains of Colima, Xantus.

"This is a common and abundant species, inhabiting the western and northwestern parts of Mexico. I found it equally as common in Tehuantepec as in the region of Mazatlan, where its loud shrill notes of hip-se-dee, hip-se-dee, may be heard at all seasons of the year, but more particularly during the breeding season, when it is excessively garrulous. It is more frequently met with in the neighborhood of fresh water streams and lagoons, and I have often observed them dart into the water after water insects and minnows that were swimming near the surface, not unlike the kingfisher; but they usually pursue and capture on the wing the larger kinds of Coleoptera and Neuroptera, swallowing its prey entire after first beating it a few times against its perch. They are usually in pairs, but I have also seen as many as twenty about a stagnant pool, watching its turbid water for insects and small fish, for which they seem to have a great partiality.

"The nest of this species is very large, and its construction differs from all the Tyrannidæ of which I have any knowledge, except *M. texensis*. It is dome-shaped or covered, with the entrance on the side, whilst the other species build a nest saucer-shaped. The nest of the Bull-headed Flycatcher is usually placed in the forks of the branches of very thorny trees, twenty-five or thirty feet from the ground; it is composed of very coarse material of either straw or lichens, sometimes of both; the lining, however, is of firmer and more elastic fibres. Other birds sometimes make their nests in the same or nearest tree; such as *M. texensis*, *C. melanicterus* and *I. pustulatus*.

"The eggs of this flycatcher are usually five in number; they are of moderate size, rather lengthened, of a light cream color, with a small reddish speck; the shell is delicate and easily broken."

116. *Myiodynastes luteiventris* Bp.
Mazatlan, Grayson, Xantus; Mts. of Colima, Xantus.

"Not a common species; inhabits the tall trees of the woods. I have only met with it in the months of May and June, at which time they were nesting. I have also found it near Tepic, in the State of Jalisco, in the month of May. As I have not met with a single bird of this species during the winter months, I am led to the conclusion that they migrate southward after the breeding season is over."

117. *Pyrocephalus rubineus* var. *mexicanus* Scl.
" *mexicanus* Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 330.
Mazatlan, Grayson; Plains of Colima, Xantus.

"Abounds in Western Mexico, throughout a greater portion of which it is a constant resident. I found it along the entire route from Tepic to the City of Mexico. Its favorite resort is along the borders of small streams or stagnant pools, where it perches upon some low dry branch, from whence it darts upon the skimming water flies and Hymenopterous insects that resort to such localities. It seldom perches upon a high tree, and is never met with in the thick forests. They are very abundant in the vicinity of Tepic, where I found several of their nests in May and June. The nests were always over the water of a lagoon, or the river of Tepic, generally in the fork of a small thorny bush without leaves, and densely covered with gray lichens or moss; so nearly does it resemble the lichens among which it is placed as to render its detection difficult, were it not for the birds themselves, who exhibit great uneasiness when their nest is approached. The eggs are five in number, very delicate, of a cream color, with purplish-brown spots."

118. *Mitrephorus phœocercus* Scl.
Mazatlan, Grayson, Bischoff.

119. *Empidonax flaviventris* var. *difficilis* Baird.
" *difficilis* Proc. Bost. Soc. of N. H., XIV., p. 279.
Mazatlan, Tres Marias, Grayson; Plains of Colima, Xantus.

"Found in the vicinity of Mazatlan, quite common; also at Tepic and the Tres Marias Islands. All the specimens procured by me were in the winter and spring months. I am not certain that it remains throughout the summer."

120. *Empidonax traillii* var. *pusillus* (Sw. and Rich.).
Mazatlan, Grayson.

121. *Contopus virens* var. *richardsoni* (Sw.).
Mazatlan, Grayson.

122. *Contopus pertinax* Cab. et Hein.
Tepic, Mazatlan River, Grayson; Plains of Colima, Xantus.

"This flycatcher is found here at all seasons, and at Tepic."

123. *Myiarchus mexicanus* (Kaup.), (*cooperi* Baird).
" " Proc. Bost. Soc. of N. H., XIV., p. 278.
Mazatlan, Tres Marias, Grayson.

"This large flycatcher I found in the vicinity of Guadalajara, Tepic, and quite common in the *tierra caliente*; also a few specimens procured in the Tres Marias Islands.

"I discovered the nest in a hollow stump about five feet from the ground; the hole was vertical, and at

the bottom, about a foot from the top, was the nest, composed of hair, wool, and the castings of a snake; the hole was just large enough to admit my hand to extract the eggs, five in number, which are of a cream color, with numerous reddish-brown splashes."

124. *Myiarchus lawrencii* (Giraud).
" " Proc. Bost. Soc. of N. H., XIV., p. 279.
Mazatlan, Tres Marias, Grayson; Plains of Colima, Xantus.

"Common and resident in the Marias; found also on the main-land in this locality, but not so numerous."

125. *Myiarchus cinerascens* Lawr.
Mazatlan, Grayson.

"Inhabits the woodland districts; common all the year."

126. *Tyrannus melancholicus* var. *satrapa* Cab. et Heine.
Mazatlan, Grayson; Plains of Colima, Xantus.

"This is one of the most common flycatchers in Northwestern Mexico, and is pretty well distributed throughout all of the interior. They inhabit the open country usually in pairs, and are constant residents of the locality to which they have become attached, seldom migrating to any great distance. They are very pugnacious during the breeding season, attacking and pursuing every bird, particularly the crows and hawks that come in the neighborhood of their nests. It performs some beautiful evolutions in the air when in pursuit of the various winged insects upon which it preys."

127. *Tyrannus melancholicus* var. *couchii* Baird.
Mazatlan, Grayson.

128. *Tyrannus vociferans* Sw.
Plains of Colima, Xantus.

129. *Tyrannus verticalis* Say.
Tepic, Grayson; Plains of Colima, Xantus.

130. *Tyrannus crassirostris* Sw.
Megarhynchus crassirostris Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 329.
Rio Mazatlan, Grayson.

"This large and handsome flycatcher is a habitant of Western Mexico, and perhaps its geographical range extends further south. Unlike most of the flycatchers, it invariably perches upon the topmost branches of the tallest trees, always preferring a withered branch or leafless tree, where its vision is unobstructed whilst calmly waiting for its prey to pass, which consists of the larger beetles, and other winged insects. When one of them passes within range of its keen vision, it immediately gives pursuit, and if successful in capturing it will return to its perch, and after beating its prize on the branch until dead, or stunned, swallows it entire. When sitting upon its lofty perch quietly surveying the scene around, it has a proud and kingly appearance, seeming to disdain to turn his head toward the lower brushwood, where his smaller congeners are pursuing their more humble avocation in darting at, and snapping up, the smaller winged insects. They are generally found in pairs, and build their nests upon a horizontal branch of very large and tall trees, where they are inaccessible to the naturalist. During the breeding season they are very tyrannical, attacking with ferocity every bird, hawk, crow or vulture, that should happen to approach too near their domicil."

Fam. Cotingidæ.

131. *Tityra personata* Jard. and Selb.
Mazatlan, Grayson, Bischoff; Sierra Madre, Xantus.

"Generally seen in very lofty trees, either in small flocks, but more usually solitary, or in pairs. It feeds on various kinds of fruit, as also insects which I have seen it dart after, like the flycatchers. I have found it in this locality in the months of November, February, April and June. It doubtless breeds in the mountainous regions of this latitude. It has no song, the voice being rather harsh."

132. *Hadrostomus aglaiæ* var. *affinis* Elliot.
" " " Proc. Bost. Soc. of N. H., xiv., p. 279.
Tres Marias, Grayson.

"Not numerous upon the islands, usually met with in the thick woods. Not found upon the main-land in the locality of Mazatlan."

133. *Hadrostomus albiventris* Lawr.
" " Ann. Lyc., N. Y., viii., p. 475.
Mazatlan, Grayson, Bischoff; Plains of Colima, Xantus.

"I have only seen one bird of this species, a male shot in February."

Fam. Momotidæ.

134. *Momotus mexicanus* Sw.
Mazatlan, Grayson, Xantus, Bischoff; Plains of Colima, Xantus.

"This curious bird inhabits the darkest woods of the *tierra caliente*. It breeds in the ground like the kingfishers; the eggs are three to four, clear white, and elliptical in shape. A constant resident in this locality, and quite common in Tehuantepec. It subsists chiefly upon insects."

Fam. Alcedinidæ.

135. *Ceryle alcyon* (Linn.).
" " Proc. Bost. Soc. of N. H., xiv., p. 284.
Mazatlan, Tres Marias, Grayson.

"Common at all seasons."

136. *Ceryle torquata* (Linn.).
Mazatlan, Grayson.

"This species preëminently exceeds all others of its genus in size; one bird at a little distance off, when seen in its usual haunts, would be apt to be taken for the common Belted Kingfisher, its habits and general appearance being similar; but upon a near investigation we find a bird of much larger size, the colors and markings of some parts of its plumage different, its notes, too, are less clamorous and more feeble.

"I have seen the largest kingfisher only near the sea coast, in the vicinity of Mazatlan River, but not on that stream. They seem to prefer the stagnant pools and lagoons, whose waters are murky and densely shaded with overhanging trees; here upon some dried branch it sits quietly watching the opaque water for whatever finny creature may make its appearance upon the surface, when if not too large, it instantly darts or plunges headlong upon it; after securing the prey in its powerful bill, it bears it to the perch, and beating it a few times upon the perch swallows it entire. Small fishes constitute almost its principal food, but frogs and small water reptiles are often struck and devoured by it. This species does not seem to be so wary as its near congener, the Belted. I have approached it quite near, in order to observe its habits, and it appeared to be

very little concerned at my presence. In examining the stomach of one shot by me, I found it crammed with the small fry peculiar to muddy pools, among which was a mud catfish of considerable size. It doubtless breeds in holes scratched in sand cliffs, like the other members of this family, but I have never encountered the nest."

137. *Ceryle amazona* (Lath.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 328.
Mazatlan, Grayson; Tupila River, Xantus.

"This handsome species is not common, but I have found it about the Rio Mazatlan at nearly all seasons. It appears to be a constant resident."

138. *Ceryle americana* var. *cabinisi* (Tsch.).
Mazatlan, Grayson, Xantus; Tepic, Grayson; Plains of Colima, Tupila River, Xantus.

"This handsome little species usually inhabits the small fresh water streams, especially those of the mountains, and sometimes the estuaries on the sea coast. In the region of Tepic it is quite common, and I saw it in several localities from that point on the road to Guadalajara. It is a constant resident."

Fam. TROGONIDÆ.

139. *Trogon ambiguus* Gould.
" " Proc. Bost. Soc. of N. H., XIV., p. 272.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 326.
Mazatlan, Tres Marias, Grayson.

"This richly plumaged bird is a habitant of the warmer regions of Mexico, from Sinaloa to Central America, on the west side. It is to be met with only in the dark forests of the *tierra caliente*. It breeds in the hollows of trees like the parrots; incubates in June and July."

This species has been in some cases mistaken for *T. mexicanus*; although much alike in general coloring, they may be readily separated by the colors and distinctive markings of the tail.

T. ambiguus has the central tail feathers coppery-red, with a rather broad terminal black bar; the outer feathers are brownish-black at their bases, with their ends white, the intermediate portion of these feathers is white, marked on both webs with very narrow irregular freckled lines of black, or as expressed by Prince Bonaparte, "*nigro vermiculatis*."

In *T. mexicanus* the central tail feathers are bluish-green, ending narrowly with black; the lateral feathers are black ending with white, but the white color of the ends not evenly defined, as in *T. ambiguus*; the outer webs are very regularly barred with white, and the margin of the inner webs marked with white indentations.

T. mexicanus is probably peculiar to Eastern Mexico; my specimen came from Jalapa. It is accurately figured by Swainson (Zool. Ills., 2d series, pl. 82).

140. *Trogon citreolus* Gould.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 327.
Mazatlan, Grayson.

"Well distributed throughout the forests of the *tierra caliente* of this region. I found it also in Tehuantepec. Native, and does not migrate."

This has been confounded with *T. melanocephalus* from Eastern Mexico and Honduras, but they may easily be distinguished from each other by the extent of white in the lateral tail feathers; in *T. melanocephalus*, the white occupies about an inch of the end of each of the outer three feathers, and is evenly separated from the black of the rest of the feather; whereas the exposed portion of the outer lateral feather in *T. citreolus* is entirely white, the next nearly so, and the third feather irregularly white at the end. Numerous specimens are in Prof. Sumichrast's collection from Tehuantepec.

Fam. Caprimulgidæ.

141. *Chordeiles texensis* Lawr.

Mazatlan, Grayson.

"This I have found to be a common species in Western Mexico, particularly in the vicinity of San Blas and Mazatlan. I also found it in Tehuantepec. Like all the birds of this genus, it rests quietly during the day upon the ground, or some old moss-covered log, darkly shaded, and in the most gloomy and secluded parts of the forest. They will suffer themselves to be almost trodden upon at times before taking wing, and were they to remain quiet they could scarcely be perceived, so nearly are they of the color of the withered leaves or the mossy log on which they rest.

"Its flight is easy and graceful, at times skimming low to the earth, and at others soaring to a great height whilst in pursuit of nocturnal insects, upon which it chiefly subsists; they usually make their appearance a little after sunset in considerable numbers.

"The egg is deposited on the withered leaves without the least appearance of a nest, in some retired spot in the woods; there are sometimes two eggs, but usually one, of a cream color."

142. *Nyctidromus albicollis* (Gm.).

" " Proc. Bost. Soc. of N. H., xiv., p. 273.

Mazatlan, Plains of Colima, Xantus; Tres Marias, Grayson.

Fam. Cypselidæ.

There are no specimens of this Family in any of the collections from Western Mexico, but on Col. Grayson's list there are the English names of three species, viz. —

Chimney Swift, Black Swift, Largest Swift.

In the absence of specimens these cannot be identified.

Fam. Trochilidæ.

143. *Thalurania lucia* Lawr.

" " Proc. Bost. Soc. of N. H., xiv., p. 284.

Tres Marias Islands, Grayson.

144. *Florisuga mellivora* (Linn.).

" " Proc. Bost. Soc. of N. H., xiv., p. 284.

Tres Marias, Xantus.

145. *Calothorax lucifer* (Sw.).

Trochilus " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 329.

Sierra Madre, Grayson; ex Finsch.

Dr. Finsch has this species in his list of some birds obtained from Col. Grayson's collec-

tion. There are no specimens in any of the collections from Western Mexico received by the Smithsonian, nor do I notice any humming bird referred to by Col. Grayson that can be this species.

146. *Petasophora thalassina* (Sw.).
" " Proc. Bost. Soc. of N. H., xiv., p. 284.

Tres Marias, Xantus.

147. *Heliomaster leocadiæ* (Bourc.).
Mazatlan, Grayson.

148. *Cyanomia quadricolor* (Vieill.).
Mazatlan, Guadalajara, Grayson.

"Summer visitant; very rare; shot in July."

149. *Cyanomia guatemalensis* Gould.
" " Proc. Bost. Soc. of N. H., xiv., p. 284.

Tres Marias, Xantus.

150. *Pyrrhophæna graysoni* Lawr.
" " Proc. Bost. Soc. of N. H., xiv., p. 283.

Tres Marias, Grayson.

"This large and handsome species is abundant and peculiar to the Islands of the Tres Marias."

151. *Pyrrhophæna cinnamomea* (Less.).
Mazatlan, Grayson.

"A common species in the entire Pacific slope of Mexico; it is a constant resident. This resembles the Tres Marias Islands species (*P. graysoni*), but is much smaller, and is not found upon the Marias.

"The nest of this species is beautifully formed like a small cup, attached to a very slender branch or twig; the materials of which it is composed are the down of plants, woven and cemented together with the silken threads of caterpillars' or spiders' webs, and the whole of the outside covered with the most delicate lichens. I procured the nest in August; it contained three eggs."

152. *Circe latirostris* (Sw.).
" " Proc. Bost. Soc. of N. H., xiv., p. 282.

Mazatlan, Tres Marias, Grayson.

"This species is common in the *tierra caliente* to Tehuantepec, and abundant in the Tres Marias Islands."

153. *Chlorostilbon insularis* Lawr.
" " Proc. Bost. Soc. of N. H., xiv., p. 284.

Tres Marias, Grayson.

Fam. Cuculidæ.

154. *Crotophaga sulcirostris* (Sw.).
Mazatlan, Grayson, Xantus, Bischoff; Tepic, Grayson; Plains of Colima, Xantus.

"This is a common species in this locality, and throughout western *tierra caliente*. They associate in small flocks of eight or ten, and are fond of picking the ticks off the cattle. It does not migrate. The nest is

usually built in a thorny tree or bush, at a moderate height, and composed of thorns and dried twigs exteriorly, and lined with fibrous roots; the eggs are usually five, the outside of the shell is rough and white, the inside is green."

155. *Piaya ridibundus* (Gm.), (*mexicanus* Sw.).
Pyrrhococcyx mexicanus Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 356.
Mazatlan, Grayson, Xantus, Bischoff; Tupila River, Plains of Colima, Xantus.

156. *Morococcyx erythropygia* (Less.).
Mazatlan, Grayson.

157. *Coccyzus americanus* (Linn.).
Mazatlan, Grayson.

"A summer visitant; makes its appearance in June, and disappears about the middle of September. Usually inhabits the mangrove swamps in this locality, where it breeds."

158. *Geococcyx mexicanus* (Gm.).
Mazatlan, Grayson, Xantus.

"This remarkable bird, which the Mexicans call 'Churea, or Correa del Camino' (Road-runner), so called from the habit it sometimes has of running along a path or road — seldom fails to attract the attention of the traveller by its solitary and peculiar habits, and often, too, in the mountainous regions and desert countries, where no other living creature is to be seen. Although met with in such localities, it is, however, not entirely confined to them, as it is an equal habitant of some portions of the thinly wooded parts of the *tierra caliente* of the West, where the trees are scrubby and the country open, as the barren and rocky great central plains of Mexico. It seems to prefer a hilly country but scantily supplied with vegetation, where the numerous species of Cacti form impenetrable thorny thickets. Here the Road-runner wanders in solitude, subsisting upon grasshoppers, mice, lizards, etc.

"It is most usually met with upon the ground, and as soon as it discovers the presence of danger, or the intruder, instantly runs off with remarkable fleetness to the nearest thicket or hill, where it generally escapes from its pursuers, either by concealment, or a short flight from one hill to another. If a tree with low branches be convenient it will spring into that, and soon reaching the top will fly off to the distance of an hundred yards or more; it appears to rise from the level ground with much difficulty. It is very quick in its motions, active and vigilant; indeed its fleetness enables it to elude its pursuers, although one may be mounted on a good horse, or a dog may be in the train; but this is only for a short distance, as it could soon be run down by the horse or dog, were not some convenient thicket or hill near, from which to take its flight from the latter, or conceal itself among the branches of the former."

Fam. Picidæ.

159. *Campephilus guatemalensis* (Hartl.).
Mazatlan, Grayson; Rio de la Ameria, Xantus.

"This fine species is common in the larger forests, and a constant resident."

160. *Dryocopus scapularis* (Vig.).
Mazatlan, Grayson, Xantus; Plains of Colima, Tupila River, Xantus.

"Common, and well distributed in the *tierra caliente*; a constant resident."

161. *Picus scalaris* var. *graysoni* Baird.
" " Proc. Bost. Soc. of N. H., xiv., p. 273.
" *lucasanus* Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 354.
Mazatlan, Grayson, Xantus; Tres Marias, Grayson.

"I found this species abundant in the Islands of the Tres Marias, where it is a constant resident. It there bores its nest in the tall and soft flower stem of the maguey plant. It is also common upon the main-land in this locality. It subsists entirely upon insects."

Prof. Baird considers the bird from Mazatlan and the Tres Marias to be a variety of *P. scalaris*, to which he has assigned the name given above; it more resembles the typical *P. scalaris* than it does *P. lucasanus*, to which Dr. Finsch refers it. *P. lucasanus* is also a race of *P. scalaris*, but with longer wings, bill, and tail. The characteristics of the different varieties of *P. scalaris* will be pointed out by Prof. Baird in his new work on the Birds of North America, soon to be published.

162. *Sphyrapicus varius* (Linn.).
Plains of Colima, Xantus.

163. *Melanerpes formicivorus* (Sw.).
Tonila, Jalisco, Xantus.

164. *Centurus elegans* (Sw.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 356.
Mazatlan, Grayson.

"Common visitant; also in Guadalajara, Tepic and Sonora.

"This handsome woodpecker is one of the most common species inhabiting the region of Mazatlan, and is noted for boring its nest in the Giant Cactus (*Cereus giganteus*), which, with wonderful perseverance and labor, amid the innumerable sharp spines of this singular plant, it picks out a hole projecting downwards, sufficiently ample for its nest. The inner wood of this cactus is very tough and fibrous, and it really seems astonishing that the bird is at all able to penetrate to the depth at which it generally forms its nest. The entrance is just sufficient to admit one at a time, but gradually widening as it descends to the depth of six or eight inches, where the eggs are deposited on the bare wood. Both male and female work at the nest until finished. They also feed upon the fruit of this plant, which, when ripe, is the most beautiful carmine red.

"The nest once made is used for some years after, if not too much distorted by the growth of the plant. This woodpecker, however, does not confine itself exclusively to the cactus for making its nest; the smooth trunk of the palm is also a favorite; sometimes as many as two or three nests may be seen in the stem of one palm, and frequently the tree is ultimately destroyed from this cause in a singular manner. The small seeds of the Wild Fig (*Ficus americanus*) are deposited in the woodpecker's nest, either by bird or bat, which the moisture of the rainy season causes to germinate, and the peculiarly rapid growth of this tree, soon after germinating, sends to the ground a tendril, which takes root in the moist earth, and in a few years the slender palm is entirely enveloped in the powerful embraces of this giant of the woods. I have often seen the singular vegetable phenomenon of the crown of the palm projecting from the body and above the wide spreading branches of the wild fig, thus having the appearance of one trunk and two different heads.

"The eggs are generally three in number, and of a transparent white."

165. *Centurus uropygialis* Baird.
Mazatlan, Guadalajara, Tepic, Grayson.

"To be met with at all seasons of the year in some localities, not abundant. It bores its nest in decayed trees, and sometimes in the stem of the palm."

Fam. PSITTACIDÆ.

166. *Sittace militaris* (Linn.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 352.

Mazatlan, Grayson.

"This magnificent species inhabits the western part of Mexico; found only in that belt of land known as the '*tierras calientes*,' which lies between the seacoast and the Cordilleras chain. Here it migrates from one locality to another in quest of food suited to its taste, but never crossing the principal chain to the eastward. I have found it, however, very far up the mountains, at an altitude of three or four thousand feet, when such aliments as they were partial to being in season drew them from the lowlands to the mountains. It may be found at all seasons of the year near the seacoast, from Mazatlan southward to Acapulco, but they are more particularly abundant in the region of Rio Mazatlan, where they find plenty of subsistence in the great forest here abounding.

"The Guacamayo is so called by the natives from the fact that it never descends to the ground but once during the year, and that is in the month of May; hence the name literally translated means 'May Guaca.' They alight upon the ground at this season of the year in search of a certain kind of hard nut, of which they are very fond, and no longer find in the trees which bear it. The tree of this nut the Mexicans call 'Ava,' a species of 'Nux Vomica'; both the milky sap of the tree, as well as the fruit, are deadly poison to any other animal but this parrot. The natives use the sap for stunning fish. The tree grows near the borders of rivers, or in rich alluvial valleys, to a large size. The wood is white and tough, the outer bark armed with short and sharp spines; the leaf is broad and ovate; the pod that contains the fruit is spherical, and about twelve inches in circumference, divided into sixteen sections, in each of which is the button-shaped kernel. The shell is exceedingly hard, but the enormous bill and powerful jaws of the Guacamayo enables it to split each one of the sections with apparent ease. From the time this nut commences to ripen in December until it disappears about the beginning of spring, it forms the principal article of subsistence for this macaw. It also feeds upon the small cocoanut, or nuts of the 'Royal Palm,' which are also very hard, but not proof against the strong bill of this parrot. The weight of the Ava ball, when green, exceeds a pound, yet I have seen with surprise these parrots after gnawing off the tough stem, handle it in their huge claws without inconvenience, and even fly a short distance with it in their beaks. It also feeds upon various species of Acacia beans, together with other kinds of wild fruit; the corn fields are sometimes visited by it.

"The Guacamayo is gregarious, except during the breeding season, but continue in pairs throughout the year. When migrating to some distance they pass at a great height, flying in pairs, uttering their discordant and harsh cries. They congregate for many miles around to some chosen spot to roost, which they continue to visit for many months, roosting upon the topmost branches of the tallest trees.

"They breed in the holes of trees, usually in the Higuera, or Wild Fig, which is the largest tree of these forests, depositing their eggs upon the bare wood; the eggs are white, two in number, and a little less than those of the common hen; their breeding season commences in April, and both male and female perform the duties of incubation."

167. *Conurus holochlorus* var. *brevipes* Baird.
" " Proc. Bost. Soc. of N. H., XIV., p. 298.

Socorro Island, Grayson.

"Upon stepping on the shore of this island for the first time, I felt as one always feels when entering upon a strange land, where man has but seldom made his footprints, and where all was silent, but the melodies of the little songsters that gazed with wonder into my eyes. This feeling of interest or curiosity was the more augmented as I entered a grove of green trees that sheltered numbers of the handsome green parrots that climbed among their branches, or sat near the ground on some low twigs, caressing each other, looking at me with silent astonishment, without appearing to have the least sense of fear at my presence. I was the first human being in all probability they had ever beheld; how little they suspected that man, the destroyer, now stood before them, with the death dealing instrument on his shoulder. With a tender solicitude for their unsophisticated tameness, I felt a conscientious delicacy in shooting one, even for a specimen; but when I remembered that I came for the purpose of making ornithological collections, and that a few of them were

required for the advancement of the science, as well as a new addition to the drawings in my portfolio, I no longer hesitated, but selecting the most adult and distant one from me, fired and killed it. The report of my gun awakened the entire grove from its dreamy spell. The greatest tumult ensued; they were terror stricken, but they knew not the cause; one of their number lay weltering upon the ground in the agonies of the last struggle for life. Around this they gathered, unmindful of my presence, perching upon the low brush over it, and even upon the ground, when suddenly their chattering, whistling voices ceased, and they all seemed to gaze with mute amazement, doubtless for the first time, on the strange mystery of death.

"I soon found that I did not require my fowling-piece to procure specimens; they were so remarkably tame as to be easily taken with a running noose fixed on the end of a rod. Three cages were filled by the boys, but were unfortunately left, owing to our sudden and unexpected departure from the island. I, however, brought away a sufficient number of skins."

168. *Conurus petzii* (Hahn.).

Mazatlan, Grayson, Bischoff; Plains of Colima, Manzanilla Bay, Rio de Coahuyana, Xantus.

"This species is common and resident."

169. *Chrysotis levaillantii* Gray.

" " Proc. Bost. Soc. of N. H., xiv., p. 271.

Tres Marias, Grayson; Tupila River, Rio de Coahuyana, Xantus.

"It is only within very recent years that one of the Tres Marias Islands has become partially inhabited by the cutters of Cedra, and as recently as 1865, when I visited these islands for the first time, I found these birds so tame and unsuspecting at the approach of a human being, as to be easily taken by simply putting a running noose of twine upon the end of a slender pole, and slipping it gently over the head while they are busy feeding among the low branches, or quietly sitting upon a limb of a tree. Many of the parrots are captured by the woodcutters and sold to the vessels touching there for a cargo of timber. They are also carried to Tepic, San Blas, Mazatlan, and other points on the coast, and sold at from one to five dollars. Upon a subsequent visit to these islands, in 1867, on my return from Socorro Island, I found that their numbers had diminished considerably, and they had become so shy as to be difficult to approach; they had learned the arts and tricks of man, and kept him at a respectful distance.

"I saw nests of this parrot, all in the hollows of large trees, one only of which I was able to reach; this was in a large smooth bark tree, known here as 'Palo Prieto'; the eggs (two in number) lay upon the bare rotten wood, which had been a little scooped out, forming a slight indentation. The eggs are a clear white, a good deal larger than those of a tame pigeon, and of an elliptical form."

170. *Chrysotis albifrons* (Sparrm.).

" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 352.

Mazatlan, Grayson, Bischoff.

"This lovely species inhabits the warmer regions of Western Mexico, and is closely allied to the Red-fronted Parrot; although it is smaller, and its plumage more brilliant, yet its natural habits are so nearly similar that the description of one would answer for the other. They are found in the same localities, and subsist upon the same kind of food. But the flocks keep separate, never assimilating with its near congener. They are, however, not so numerous as the red-fronted species. It is easily domesticated when taken young, and can be taught to utter words very clearly. It is a great favorite with the natives."

171. *Chrysotis finschii* G. R. Gray.

Mazatlan, Grayson, Xantus, Bischoff; Rio de la Ameria, Colima, Xantus.

"The Red-fronted Parrot is distinguished by a rather prominent forehead of peach red or dark carmine, the feathers composing it are short and bristly; the bill nearly white or pale yellow, and the tongue black. It is

a handsome and well known species in western Mexico, inhabiting the region of *tierras calientes*, or western slope of the Cordilleras, more abundant near the seacoast than the mountainous regions, and its geographical distribution extends from southern Sonora to Tehuantepec, and perhaps farther south. They are gregarious, assembling in large flocks, and are more numerous in the region of Mazatlan than any other portion of the country that I have visited. The forests in some localities, particularly where some kinds of fruit are in season, appear at times to be alive with them, only in the morning and evening, however, when they are seeking for their favorite food; they are then flying hither and thither through the woods, or perching and climbing among the branches that contain the fruit they are in search of, keeping up at the same time an incessant din of chattering, and this, mingled with the loud and harsh screams of the large green macaws, produces a very discordant and disagreeable forest music. They often visit the cornfields or milpas in great numbers, about the time the green corn or maize commences to mature, committing great depredations, and often destroying the small milpas of the natives unless they are guarded.

"If taken from their nest before they are fledged, they may be taught to pronounce some words very distinctly, as well as sing and whistle tunes. Their season for incubation commences in the latter part of March, or early part of April, at which time they quietly divide off into pairs and seek a hollow in some large tree, where they deposit their eggs without any more nest than the bare rotten wood, which is generally smoothed off a little by the birds, both of which perform an equal part in the task of incubation; the eggs, two in number, are a clear white; the young are fed by the parents for some time after they are able to fly. The pair from the same nest generally remain together through life. By an extraordinary provision of nature, it is seldom (if ever) that the young are of the same sex, but always male and female.

"It is the presumption of many that parrots do not drink water in their wild state, but this is a mistake; they have their watering places, which is on some secluded brook overhung with trees, where they go about the hour of ten or eleven, A.M., to drink, and often bathe also."

172. *Psittacula cyanopyga* De Souancé.
" " Proc. Bost. Soc. of N. H., XIV, p. 271.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 353.

Mazatlan, Grayson, Bischoff; Tres Marias, Grayson; Manzanilla Bay, Xantus.

"The smallest of parrots, and quite abundant in the region of Mazatlan and the Tres Marias Islands; they associate in considerable flocks; their flight is much like a flock of common rice birds; resident."

Fam. STRIGIDÆ.

173. *Speotyto cunicularia* var. *hypogæa* (Bp.).
Athene cunicularia Proc. Bost. Soc. of N. H., XIV, p. 270.

Tres Marias, Mazatlan, Grayson.

"Found usually along the open sea beach at night in search of small crabs, upon which it chiefly subsists in the Marias; also met with upon the main-land in this locality."

174. *Micrathene whitneyi* (Cooper).
" " Proc. Bost. Soc. of N. H., XIV, p. 300.

Socorro Island, Grayson.

"Three specimens of this least of all owls were captured on the island. They were always found among the branches of the evergreen low trees. It seems to feed entirely upon the small land crabs, which are abundant near the sea."

175. *Glaucidium ferrugineum* (Max.).

Mazatlan, Grayson.

"A common species in this locality, and resident."

176. *Glaucidium infuscatum* var. *gnoma* Wagl.
Mazatlan, Grayson; Colima, Xantus.

177. *Syrnium virgatum* Cass.
Mazatlan, Grayson; Colima, Xantus.

178. *Strix flammea* var. *pratincola* Bp.
" *pratincola* Proc. Bost. Soc. of N. H., XIV, p. 270.
Tres Marias, Grayson; Colima, Ameria River, Xantus.

"This species is common all over Mexico; I discovered a nest in the hollow of a tree on the Rio Mazatlan."

Fam. FALCONIDÆ.

179. *Circus cyaneus* var. *hudsonius* (Linn.).
Mazatlan, Grayson.

180. *Accipiter fuscus* (Gm.).
Mazatlan, Grayson.

"This well-known and widely distributed species is very common in Western Mexico, where I have found them in all seasons of the year, and in different stages of plumage. One day I witnessed an act of this hawk which goes far to illustrate its habits of perseverance in hunting out the game it may be in quest of; a brood of half grown chickens was attacked by it, one of which had taken shelter beneath the bottom rail of a fence; there was barely room between the rail and the ground to admit the fowl; the little hawk, after perching for a few moments on the top of the fence, lit upon the ground, and actually reached its slender claws under the rail, dragged the unfortunate chicken from its hiding place, carried it off a hundred yards to the bottom of a dry creek, where I followed it up and recovered the chicken, with which he was unable to rise above the bank of the creek. Field mice also constitute a part of its subsistence, but to quails and young chickens he seems to give a decided preference. I have never been able to find the nest of this hawk, though I am well convinced it breeds in this region."

181. *Accipiter cooperi* Bp.
Mazatlan, Grayson.

"Like the Sharp-shinned Hawk, and one or two others of a closely allied species, it has the habit of flying very swiftly near the ground when hunting for its prey, as if to come upon it suddenly without being seen; when thus upon its tour of rapine, the birds lay close under cover, well knowing the brave and desperate spirit of this keen little hawk. At last he surprises a flock of quail, his favorite game; onward he dashes among them; the affrighted birds are so confused and panic-stricken, as scarcely to know which course to flee; they scramble in every direction, but the reckless hunter in an instant has selected one, and furiously dashes headlong amidst the brambles and grass in which the unfortunate game endeavors to make its escape, but too late — the crying and plaintive notes of the poor quail are heard; he has seized it in his powerful and sharp claws, and immediately bears it off, flying near the ground, until he finds some secluded spot beneath a canopy of bushes and vines, where either upon a prostrate log or on the ground, it devours its prey at leisure.
"I have found this hawk not uncommon in the locality of Mazatlan during the winter months."

182. *Asturina plagiata* (Licht.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 325.
Mazatlan, Grayson.

"I have met with this hawk in all of Western Mexico wherever my rambles have led me, from Tehuantepec to Sinaloa. It is rather sluggish in its habits, sitting for hours upon the limb of some decayed tree in apparent listlessness, permitting you to approach very near without moving from his perch, then flying but a short

distance before again alighting. Although its flight is vigorous and quick, and the feet and claws sharp and strong, yet its prey consists of the more humble and weaker creatures of the wood and field, such as lizards, small snakes, field mice, etc. These are indeed his staff of life. But in the general breeding season of birds, when the young are not fully fledged, and are just beginning to try their tender wings from the parent nest, it is then it finds opportunities to change its usual diet of lizards and snakes, to the more tender young birds of any species that may come in his way. He often visits the poultry of the natives and carries off young chickens; will follow the Chachalaca (or wild tree chicken) and her young brood through the densest woods, in his skulking way, until an opportunity offers to pounce upon one of them, thus keeping the mother constantly on the alert; she will defend her brood with great courage when he makes the attack, but he is often too quick for her vigilance, and carries off one at a time from day to day, until her precious chicks are mostly all devoured by the sly manœuvering of this hawk. The nest is generally placed in the branch of some very thorny acacia, and inaccessible in consequence of the thorns; it seems to be composed of dry twigs, grass and moss; incubation takes place as early as February and March."

183. *Micrastur semitorquatus* (Vieill.).
Mazatlan, Grayson.

"Among the great variety of hawks to be met with in a single day's excursion in the locality of Mazatlan, none are so easily recognized as this peculiar and interesting species. I have only found it in the heavy forests, or the immediate vicinity of a thickly wooded country, where its slender form and lengthened tail attracts our attention as it swiftly glides through the tangled woods, with that remarkable ease which we have often noticed in the Sharp-shinned Hawk (*A. fuscus*). It appears to be strictly arboreal in its habits, and possessed of wonderful activity, either in springing from branch to branch without opening its wings, or rapidly darting through the intricacies of the brush with apparently but little difficulty. I have seldom seen one of these hawks in an open country, and have never seen one flying higher than the tree tops, where they are met with. Its wings are rather short, and its flight is performed by rapidly repeated strokes, only for a short distance at a time. It preys upon various species of wood birds, which it captures by darting upon them on the ground or in the bushes; but the Chachalaca is its favorite game; this is a gallinaceous bird, or wild chicken, about the size of, or lighter than, the common hen, and is entirely arboreal, seldom running upon the ground, but is able by its peculiarly formed feet to cling to, or spring rapidly through, the thickest branches with great agility; but this hawk follows it with equal facility, until an opportunity offers to strike its prey, then both come to the ground together, the hawk being the lighter bird. I witnessed a scene of this kind that took place when I was endeavoring to get a shot at a Chachalaca, as it was jumping about the very thick branches of an acacia, overgrown with lianes; it appeared to be in great distress, uttering its harsh notes of alarm, and spreading its fan-shaped tail; suddenly I saw one of these hawks pounce upon it, when with harsh screams of terror and pain the Chachalaca dragged his captor to the ground, where they struggled for a few moments, but the unfortunate bird was soon overcome. The struggling and screams of the Chachalaca created a great commotion among the denizens of the woods; far and near were heard the harsh cries of other members of its family, and the Urraca Magpie, with streaming tail and ludicrous gesticulations, as well as the Blue-back Jay, and other birds in the neighborhood, gathered around to witness the scene of rapine; suddenly appeared in the midst of this clamor a larger hawk (*Buteo harrisi* Aud.), which rushed at once upon the captor of the Chachalaca; unable to withstand so heavy a charge, he was compelled to give up his honestly captured prey to a superior force, thus proving the old adage that 'might is right.' The slender but compact figure of our present subject was now seen perched upon a neighboring bough, scrutinizing with a vicious eye, the more powerful but less active bird of prey, as he vainly attempted to bear off the lifeless form of the Chachalaca; but there was one yet mightier than he, I observed it for a few moments, then shot it, as also the Long-tailed Hawk, thus securing all three.

"They build their nest of dry twigs and moss, which is placed in a very tall tree, but below the higher branches; the only nest I have seen was inaccessible, therefore I regret that I am unable to describe the eggs."

184. *Geranospiza gracilis* var. *niger* (Dubus).
Mazatlan. Grayson.

"Among the great variety of the family of this region, this one seems to be the most delicately and feebly formed as well as the rarest. I have never been able to procure but two specimens, which I found near fresh

water ponds in the low grounds near the Rio Mazatlan. One shot in February had just captured a large water frog; the other was shot near the same locality in April. In the stomach of each I found partly digested the remains of frogs, and in one a small water snake. It is of a sluggish nature, sitting for hours upon the limb of a tree in apparent listlessness."

185. *Herpetotheres cachinnans* (Linn.).
Mazatlan, Grayson.

"This remarkable species is only to be met with in the thick forests of the warmer regions, its geographical range extending very probably into Central and South America. I found it equally as common in the locality of Tehuantepec as that of Mazatlan; northward its range stops in the densely wooded districts of the western and southern parts of Sonora. It is one of the most peculiar and easily identified hawks of this region, not only from its well-defined markings, its large and broadly crested head, but its well known scream of Guaco (pronounced *waco*), which is often repeated for an hour or so at a time, either late in the evening, or early in the morning. When heard at twilight amid the solemn and eternal woods of these latitudes, a feeling of melancholy is produced upon the weary traveller, far from his native land, as he threads some dark and intricate path, crowded on all sides with impenetrable undergrowth, and overhung with the arched branches of trees of immense size and strange forms. This hawk is often found in pairs, and the answer to each other's call makes, at times, a singular medley of talking and laughing together. It is seldom seen in an open country, or soaring at any great height. Its flight is a quick successive movement of the wings, passing through the woods, or across an opening with rapid ease. It subsists almost entirely upon reptiles and rodents, which its stout claws are well adapted for holding, and its rough scaly legs are armored against their bites. It sometimes, however, preys upon birds."

186. *Falco peregrinus* var. *anatum* Bp.
" " " *nigriceps* Proc. Bost. Soc. of N. H., XIV, p. 268.
Mazatlan, Tres Marias, Grayson.

"In the vicinity of Mazatlan I have, at different times, observed the American Peregrine, some of which I shot and preserved. A pair of these falcons have bred in a cliff on an island near Mazatlan, called Venado (deer) island; I discovered the eyry in the early part of April, 1862, in company with Lt. Remington, of the British navy. We were in search of the eggs of a certain species of tern, but could find no others than those of the Brown Pelican (*P. fuscus*), the nests of which were quite numerous; whilst thus occupied, we observed a pair of Peregrines flying around, and sometimes darting into a cavity in the cliff far above our heads; we attempted every means to reach the nest, but found it inaccessible. Before leaving the spot, we saw one of them enter the cavity with a bird in its claws, from which we came to the conclusion that the nest contained young. The food of the Peregrine Falcon is principally birds of all kinds, but it shows a decided partiality for the smaller species of ducks, pigeons and the like. It seldom strikes its prey upon the ground, and should a bird enter cover when being pursued, it immediately passes on in search of other objects of its fancy."

187. *Hypotriorchis columbarius* (Linn.).
" " Proc. Bost. Soc. of N. H., XIV, p. 269.
Mazatlan, Tres Marias, Grayson.

"I have found this species quite common in Western Mexico, as far west as the Islands of the Tres Marias, off the coast some seventy or eighty miles. I have shot it in the vicinity of Mazatlan, also Tepic, where it is frequently to be met with. I observed one of these hawks whilst in Tepic, perched daily upon the top branches of a tree that grew upon the plaza, being near my window where I was making some drawings, and could see all its movements. It seemed to subsist entirely upon the small Cow-pen Blackbirds, which are very numerous about the streets and vacant lots of Tepic. As soon as it captured its victim it immediately returned to this same tree, where it was devoured at leisure. I have known it to capture three of these birds from eight o'clock to twelve, M. It remained, and continued its usual avocations in the same locality nearly the whole time I remained in Tepic, from November to January."

188. *Hypotriorchis femoralis* (Temm.).
Falco femoralis Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 362.
Mazatlan, Grayson.

"This handsome little hawk may be recognized when at some distance off, while upon the wing, by its lengthened and fan-like tail. I found it not uncommon in the vicinity of Mazatlan and San Blas, where I have shot and preserved specimens in the winter months, and with many opportunities of observing its habits. It seems to prefer a sparsely wooded country, where there are scattered trees and low bushes. In its habits I am reminded at times of the Sharp-shinned Hawk (*A. fuscus*) in its stealthy manner of hunting for its prey beneath the thick foliage of the woods, flying near the ground, or perching in secluded places, from whence it watched, cat-like, for quails, ground doves, etc. It, however, may be seen at other times, falcon-like, boldly pursuing its prey in the open country, and the smaller species of ducks, as well as pigeons, plovers and sand-pipers, are attacked and captured on the wing by this swift flying little falcon. I am not aware that it breeds in this locality, not having seen one during the season of nidification."

189. *Hypotriorchis rufigularis* (Daud.).
" " Proc. Bost. Soc. of N. H., XIV, p. 269.
Mazatlan, Tres Marias, Grayson.

"We should see this species in its ethereal element to become enraptured with its graceful movements, and the wonderful rapidity of its flight. I have seen seven or eight at different times in the locality of Mazatlan, and it was a long time before I was able to procure a specimen. Whilst hunting in the vicinity of San Blas, in an old clearing, I saw one of these hawks dart at and seize a little ground dove, when it was endeavoring to make its escape by flight; this dove is a swift flyer, but the little peregrine came up with it so suddenly as to make it appear almost stationary; indeed it passed over my head like an arrow just sprung from a bow; after striking its prey it ascended to the top of one of the tall dead trees in the clearing, to make his morning repast. Again I was disappointed in not securing this hawk. I at last succeeded in shooting one near the Rio Mazatlan in the month of February, 1867. I regret I am unable to describe its nest and eggs, never having seen the eyry of this rare little falcon."

190. *Tinnunculus sparverius* (Linn.).
" " Proc. Bost. Soc. of N. H., XIV, p. 269.
Mazatlan, Tres Marias, Grayson.

"Unlike the true falcons, it feeds almost exclusively upon insects, such as grasshoppers, beetles, slugs, etc., sometimes, but rarely, it captures a field mouse or sparrow. It is very seldom seen in the woods, but is always to be met with in an open grassy country, or an old field, perched upon a stake or dry shrub, where it watches patiently from day to day for the objects upon which it preys. It may be frequently seen balancing itself in the air for a few moments, at a moderate height, and then suddenly darting to the ground for a grasshopper. The Sparrow Hawk lays its eggs in the hollow of some tree, but more frequently in a hole which the larger species of woodpeckers have made so laboriously for their own nest. The eggs, sometimes five in number, are of a pale buff color with numerous specks, or blotches of reddish brown; they are a little larger than those of the domestic pigeon; the male assists in the duties of incubation, and during this season is particularly attentive to the female. I have known this hawk on several occasions to roost in deserted houses, where beneath the roofs of such it found shelter from the inclemency of the weather."

191. *Buteo borealis* var. *calurus* Cass.
" " " *montanus* Proc. Bost. Soc. of N. H., XIV, p. 301.
Mazatlan, Tres Marias, Grayson.

"A common species in the Marias, also found in the vicinity of Mazatlan. Resident in these localities."

192. *Buteo borealis* var. *costaricensis* Ridg.
" " " *montanus* Proc. Bost. Soc. of N. H., XIV, p. 301.
Socorro Island, Grayson.

193. *Buteo nigricollis* Lath.
Mazatlan, Grayson.

"No locality that I have ever visited in my researches for the objects pertaining to ornithology equals that where the Mazatlan River forms an expansive valley near the seacoast, for the great numbers and varieties of hawks there met with. They seem to assemble in this favorite spot from far and near, and almost all the known species are represented here during the dry season. This may be accounted for from the fact that this extensive region is diversified with rudely cultivated farms, old fields overgrown with brambles and weeds, impenetrable thorny woods and forests of large trees, interspersed here and there with stagnant lagoons and lakes, through the centre of which wind the clear waters of the Rio Mazatlan. Here abounds animal life in great abundance; the old neglected fields overgrown with matted vegetation harbor innumerable field-mice and other rodents; here various species of lizards and snakes dart through the thickets when scared from their sunny beds. The lagoons furnish other reptiles; swarms of ducks and various kinds of water-fowl resort to their slimy waters; the woods are enlivened with great numbers of birds, all of which furnish to the different species of hawks their favorite prey.

"The remarkable species which heads this article I discovered in this locality; it is entirely new to me, and I have not yet seen it mentioned in any volume at my command; the specimen has been sent to the National Institution at Washington for identification. The flight of this hawk seems rather heavy, resembling somewhat the common Fish Hawk, the wings appearing very broad, and the tail remarkably short. Upon examining the contents of the stomach after skinning it, I found only the remains of fish, one of which had been but freshly devoured; it was a species of perch found in the lagoons and rivers of this region."

194. *Buteo albonotatus* Gray.
Mazatlan, Grayson.

"Not common, resident. It flies easily and gracefully, sometimes at a great height. I have seen it frequently balance itself in the air when in search of its prey, which it appeared to be watching for in the grass or weeds, where such rodents as it preys upon inhabit. I have sometimes, when it was sailing around, taken it for the Turkey Vulture, its flight and perigrinations in the air, as well as its color, at a distance, so much resembling that common bird."

195. *Craxirex unicinctus* var. *harrisii* (Aud.).
Morphnus unicinctus Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 363.
Mazatlan, Tepic, Jalisco, Grayson; Colima, Xantus.

"A common species at all seasons, in every locality."

196. *Urubitinga zonura* (Shaw).
Mazatlan, Grayson.

"This fine species is not a very common one; it is resident in the interior parts of the *tierras calientes*, and does not inhabit the vicinity of the esteros and seacoast as *U. anthracina* does."

197. *Urubitinga anthracina* (Licht.).
Mazatlan, San Blas, Grayson.

"Common at all seasons; usually found about the esteros and marshes near the seacoast, subsisting chiefly upon land crabs."

198. *Pandion haliætus* var. *carolinensis* (Gm.).
" *carolinensis* Proc. Bost. Soc. of N. H., XIV., p. 268.
Colima, Xantus; Tres Marias, Grayson.

"I discovered the nest on a rock adjacent to the shore of the northern Marias Island, with young in it, and another nest in a cactus; it is quite common about Mazatlan."

199. *Polyborus tharus* var. *audubonii* Cass.
" *audubonii* Proc. Bost. Soc. of N. H., XIV., p. 268.
Mazatlan, Tres Marias, Grayson; Colima, Xantus.

"In general appearance this resembles some of the larger hawks, and although it subsists principally on dead animals and other offal, it, however, does sometimes capture young or disabled birds, lizards, snakes and land crabs. It generally carries off its prey in the beak, but I have also frequently seen it using the claws for that purpose, as the hawks do. It walks with facility on the ground, and may often be met in the thick woods walking about in search of reptiles, etc., with as much ease as an ambulatory fowl.

"It is sluggish in its habits, and rather docile, frequenting the vicinity of towns and ranches, often in company with the Black Vulture, with whom it performs no inconsiderable part as a scavenger.

"I found the Caracara quite abundant on the Tres Marias Islands; in the vicinity of Mazatlan it is a very common species, and, in fact, all parts of Western Mexico that I have visited. After gorging themselves with offal they sit perched for hours upon a branch of a tree, or the thorny tip of a cactus, bringing to mind the supposition that this may be the celebrated eagle of the Montezumas, now the escutcheon of the Mexican banner.

"The nest of the Caracara is generally placed on trees, and sometimes said to be on rocky cliffs. One which I discovered, and had a fair opportunity of examining, was built on the huge branches of the giant cactus, about fifteen or twenty feet from the ground. The nest was large and loosely built of coarse dry twigs, and lined with grass and leaves; it contained three eggs, which were nearly ready to be hatched; they were about the size of a domestic hen's egg; the ground color a dirty white with numerous large blotches of reddish-brown and small irregular spots, more confluent around the larger end."

Fam. VULTURIDÆ.

200. *Sarcoramphus papa* (Linn.).
Mazatlan, Grayson.

"Three specimens of this species were captured in the mountains near Acaponetti, about eighty miles southeast of Mazatlan; the only place it seems in which they have been discovered in Northwestern Mexico. The three individuals were captured in this locality through the ingenuity of an old native Indian. One died (fortunately for me) after reaching Mazatlan; it was a good specimen, and a female."

201. *Cathartes aura* (Linn.).
" " Proc. Bost. Soc. of N. H., XIV., p. 267.
Mazatlan, Tres Marias, Grayson; Colima, Xantus.

"This is very numerous in Western Mexico, and I found it as far south as Tehuantepec, and in the Tres Marias. They seem to be constantly engaged upon the mission for which a wise dispensation of Providence has intended them, that of passing in large circles at a moderate height, seeking out and devouring the putrid bodies of animals, offal, and other filth, which would breed a pestilence were it not for such agencies as the Turkey Buzzard and its coadjutors."

202. *Cathartes atratus* (Bartram).
Mazatlan, Grayson.

"It may be met with in all Mexico, but is more common in the *tierras calientes*. They are gregarious at all seasons of the year, associating in considerable flocks, and when one of their number discovers a dead car-

cass, the others soon follow, when they fall to work devouring it with such greediness and pell mell confusion, as to appear like a black disorderly mass of wings and tails, making at the same time a hoarse blowing noise; often at this interesting moment, when they are the least watchful, a dog or coyote will bound in among the pile, scattering them in every direction; most of them will settle on the ground near by, whilst others will sail around, waiting patiently until the dog is satisfied, when they again commence on the carcass, and if not molested will gorge themselves to such a degree that many of the flock are unable to rise from the ground. They will frequently attack young lambs and pigs, biting off their ears and tails; I have seen a whole litter of pigs mutilated in this way; this is the only complaint ever made against this useful scavenger. They are very numerous about Mazatlan, and to a new comer present a strange scene by their exceeding tameness; they line the beach at times, feeding upon the offal there found. They may be seen sitting upon the houses and fences sunning themselves, in rows, looking very lazy indeed, but they are the scavengers, and are permitted to do just as they please. On the outer points of the port of Mazatlan, is a high peaked island near the shore, partially overgrown with low scrubby trees and cactus, called the Creston. For years the Black Vultures have made this their roosting place in company with the Gray Pelican, perching upon the low brush, and even upon the rocks, in great numbers."

Fam. Columbidæ.

203. *Columba fasciata* Say.
"Mountains," Grayson.

204. *Columba flavirostris* (Wagl.).
" " Proc. Bost. Soc. of N. H., xiv., p. 274.
Mazatlan, Tres Marias, Grayson; Sierra Madre, Xantus.

"This fine species in some localities of Western Mexico is quite abundant, particularly in the region of Mazatlan River. It frequents the larger forests, and feeds upon various kinds of berries, acorns, and the tender buds of some trees. It is partially gregarious, but is often seen solitary and in pairs. Small flocks of from twenty to fifty migrate from one part of the country to another in search of its favorite food. I have found it at a considerable height on the western slope of the Sierras Madres, feeding upon acorns, that are there in abundance in some seasons. The flesh of this pigeon is tough, and sometimes bitter to the taste, caused by the bitter acorn, and also by an astringent kind of berry, upon which they may be subsisting at the time. As a game bird it is inferior to most of our pigeons for the table, but being a large and handsome bird it is sure to attract the attention of the gunner. They are not easily approached, however, being very shy, and without the strictest caution the hunter would not be able to fill his bag with this game in a long day's tramp."

205. *Zenaidura carolinensis* (Linn.).
Mazatlan, Grayson.

"Common throughout Mexico, more so on the high central plains."

206. *Zenaidura graysoni* Baird.
" " Proc. Bost. Soc. of N. H., xiv., p. 299.
Socorro Island, Grayson.

"During our sojourn upon the island we saw and captured several of these doves, they were always alone and silent, with a melancholy look, as if lost. Two of them came separately to our camp, both of which we secured after watching their habits awhile. They were remarkably tame, appearing to be unconscious of danger, walking about on the ground picking up crumbs of bread."

207. *Chœmepelia pallescens* Baird.
" " Proc. Bost. Soc. of N. H., XIV., p. 300.
Mazatlan, Tres Marias, Socorro, Grayson.

"In Western Mexico, and particularly the Mazatlan region, it is more abundant than in any other locality, frequenting the brushy and grassy districts, especially old fields, where the rank weeds furnish them with the small seeds upon which they feed. Their flight is strong and rapid, and when first started from cover their wings produce a whirring sound, almost equal to the quail. They do not associate in flocks, but are found scattered singly or in pairs; in like manner they migrate from one place to another, more frequently solitary. The flesh constitutes a delicate morceau for the breakfast table, as it is white and juicy, but they are seldom shot for this purpose, being too small for the waste of ammunition, or the trouble of preparing them for the table."

208. *Scardafella inca* (Less.).
Mazatlan, Grayson.

"I found this little species also in Guadalajara and Tepic; it is distributed throughout Western Mexico generally, and a constant resident."

209. *Melopelia leucoptera* (Linn.).
Mazatlan, Grayson; Colima, Xantus.

"Among the varieties of doves which I have found inhabiting Western Mexico and its islands, the White-wing Dove is one of the most common and numerous. Occasionally they may be seen in considerable flocks visiting the cornfields, for the purpose of picking up grains of corn, for which it shows a decided partiality, although its chief means of subsistence consists of small seeds and berries. The white of the wing, as well as its size, renders it conspicuous game, and a kind that can always be readily found by the hunter in the woods or fields, and easily procured. They are distributed over the greater part of Western Mexico, especially the *tierra caliente* region. I found it very abundant in Tehuantepec, and it is doubtless found much farther southward; northward it extends into Sonora. The cooing of this dove is loud, and considerably varied; it is not so plaintive as that of most of the genus. Their nests are formed of small dry twigs, loosely put together on the horizontal branches of trees, at a moderate height from the ground, usually in an exposed and careless manner. The male assists in incubation, and they rear two or three broods in a season, but this is not common. They are sometimes domesticated by the natives, and become very tame and familiar; but if their wings are suffered to grow, they soon wander off and mix with the wild ones."

210. *Leptoptila albifrons* Bp.
" " Proc. Bost. Soc. of N. H., XIV., p. 274.
Mazatlan, Tres Marias, Grayson.

"This 'ground dove,' as its name indicates, is usually met with upon the ground in search of its food, or sometimes resting upon low branches, or old logs, and always in the thickest woods, out of which they are seldom seen. It walks and runs with great facility upon the ground, whilst its flight is always low amidst the bushes or underbrush, as if to conceal itself, and not long continued, usually alighting upon the ground beneath a massive canopy of underbrush, where it continues to walk or run to elude pursuit, or search for its food. When suddenly started from its retreat, the wings whir, accompanied by a whistling sound, very similar to that of the wood-cock. Its habits are solitary, never congregating into flocks, and only during the breeding season do we ever find a pair together. Differing from all our American doves, it deposits its eggs upon the ground, forming scarcely any nest; the eggs are two, and white; the young soon follow the mother, before being able to fly, like some of the gallinaceous birds."

Fam. PENELOPIDÆ.

211. *Penelope purpurascens* Wagl.
Mazatlan, Grayson, Bischoff; Tonila, Xantus.

"This fine bird is entirely arboreal in its habits, and it is only to be met with in the large forests of the warmer regions of Mexico. Its flesh is white, and nearly as good as that of the turkey."

212. *Ortalida poliocephala* Wagl.
Tupila River, Xantus.

213. *Ortalida wagleri* Gray.
Mazatlan, Grayson.

"Iris dark brown, feet gray, bare space around eye reddish-blue, gills red. Length, 26½ in.; wing, 10; tail, 12; tarsi, 3.

"This is the only species found in the locality of Mazatlan of the genus Ortalida. It is well distributed throughout the woods of the *tierra caliente*, from Sonora as far south as about the region of Colima; beyond that it is replaced by a closely allied species, which is very abundant in Tehuantepec, western side; neither of the species ever cross the Cordilleras to the eastern slope, so far as my observation is concerned."

Fam. MELEAGRIDÆ.

214. *Meleagris gallopavo* Linn.
Sierras Madres, Grayson.

"In the Sierras Madres, but does not approach the coast region."

Fam. PERDICIDÆ.

215. *Cyrtonyx massena* (Less.).
Ortyx massena Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 357
Guadalajara, Sierra Madre, Grayson.

"This remarkable species inhabits the mountainous regions of Mexico; I found it quite plentiful near Guadalajara, and they are brought in great numbers to the market in the city of Mexico, from the mountains in the interior. I have seen a few pairs in some of the western spurs of the Sierras Madres, between this and Durango."

216. *Ortyx graysoni* Lawr.
Guadalajara, Grayson.

"I discovered this partridge in flocks at a ranche near Guadalajara; it inhabited the open grassy country, in which were clusters of small trees and thickets of brambles and cacti. There were several flocks met with in this vicinity, and no where else, in one of which there was an albino. This rancho is about ten leagues northwest of Guadalajara city, situated in a valley of considerable extent, through which a small stream of water flows, and appeared to be their favorite resort. Upon the sides of the surrounding hills I saw none, but found the Massena Partridge."

217. *Callipepla elegans* (Less.).
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 357.
Mazatlan, Grayson.

"An abundant and handsome species in this locality. I also found it in the State of Jalisco and Colima, but not as far south as Tehuantepec."

218. *Callipepla squamata* (Vigors).
Durango, Grayson.

219. *Philortyx fasciatus* Gould.
Plains of Colima, Xantus.

220. *Lophortyx gambelii* Nutt.
Sonora, Grayson.

"Not found in the locality of Mazatlan, but abundant in parts of Sonora."

Fam. TINAMIDÆ.

221. *Nothocercus sallæi* Bp.
Mazatlan, Grayson.

"The present species inhabits the dark forests of the western *tierra caliente*; it is solitary in its habits, and is confined principally to walking upon the ground, feeding on various kinds of seeds, berries and insects. During the season for incubation, which is in May and June, their long peculiar whistle can be heard for some distance; at such times an expert hunter, by imitating their notes, may easily call them to him; in this way I procured most of those shot by me. Their flesh is white and excellent, more tender and juicy than that of the quail."

Fam. CHARADRIIDÆ.

222. *Ægialitis vociferus* (Linn.).
Mazatlan, Grayson.

"Very common."

223. *Ægialitis semipalmatus* (Bp.).
" " Proc. Bost. Soc. of N. H., XIV., p. 285.
Mazatlan, Tres Marias, Grayson.

"An occasional visitant upon the shores of the Marias, also upon the main-land. Specimens shot in January and October."

224. *Ægialitis wilsonius* (Ord.).
Mazatlan, Grayson.

225. *Ægialitis nivosus* Cass.
Mazatlan, Grayson.

226. *Squatarola helvetica* Linn.
Mazatlan, Grayson.

"Not common in this region. Specimen shot in October."

227. *Aphriza virgata* (Lath.).
Colima, Xantus.

Fam. Hæmatopodidæ.

228. *Hæmatopus palliatus* Temm.
" " Proc. Bost. Soc. of N. H., xiv., p. 284.
Mazatlan, Grayson, Bischoff; Isabella Island, Tres Marias, Grayson; Rio Zacatula, Xantus.

"Frequently met with in pairs upon the shores of the Tres Marias at all seasons, also upon the main-land, sometimes in flocks; it breeds in this locality."

229. *Strepsilas interpres* (Linn.).
Rio Zacatula, Xantus.

Fam. Recurvirostridæ.

230. *Recurvirostra americana* (Gm.).
Rio de Coahuana, Xantus; Mazatlan, Grayson.

"Winter visitor; not common."

231. *Himantopus nigricollis* (Vieill.).
Mazatlan, Grayson; Rio de Coahuana, Xantus.

"Makes its appearance in October, and remains until April; abundant."

Fam. Scolopacidæ.

232. *Gallinago wilsonii* Temm.
Mazatlan, Grayson; Colima, Xantus.

"Arrives in December, and is distributed in small numbers throughout the country, but not in sufficient numbers to make it worthy the sportman's attention; disappears in May."

233. *Macrorhamphus scolopaceus* (Say).
Mazatlan, Grayson.

"Not abundant; makes its appearance in October, and remains but a short time."

234. *Actodromas minutilla* (Vieill.).
Mazatlan, Grayson, Bischoff; Mazanilla Bay, Xantus.

"Common."

235. *Calidris arenaria* Linn.
Mazatlan, Grayson.

"A wandering species, sometimes found in flocks on the beach in September, October, and in the winter months, but not a constant resident."

236. *Limosa fedoa* Linn.
Mazatlan, Grayson, Col. Abert.

"Common in the winter months until late in the spring; a few remain throughout the summer."

237. *Symphemia semipalmata* (Gm.).
Mazatlan, Grayson, Bischoff.

"A common species the entire year.

238. *Gambetta melanoleuca* (Gm.).
Colima, Xantus.

239. *Gambetta flavipes* (Gm.).
Mazatlan, Grayson.

"Not abundant; met with during the winter months."

240. *Rhyacophilus solitarius* (Wils.).
Mazatlan, Grayson.

"Common."

241. *Tringoides macularius* (Linn.).
Colima, Xantus.

242. *Numenius longirostris* Wils.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 363.
Mazatlan, Grayson.

243. *Numenius hudsonicus* Lath.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 363.
Mazatlan, Grayson; Rio Zacatula, Xantus.

Fam. TANTALIDÆ.

244. *Ibis alba* Linn.
Mazatlan, Grayson.

245. *Ibis guarauna* Linn.
Mazatlan, Grayson; Manzanilla Bay, Xantus.

"Numerous, and common at all seasons."

246. *Tantalus loculator* Linn.
Mazatlan, Grayson.

"Abundant at all seasons."

Fam. PLATALEIDÆ.

247. *Platalea ajaja* Linn.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 358.
Mazatlan, Grayson.

"Common throughout the summer months; less so during the winter months, although it may often be met with in small numbers."

Fam. Cancromidæ

248. *Cancroma cochlearia* Linn.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 358.
Mazatlan, Grayson.

"Common throughout the year in some peculiar localities."

Fam. Ardeidæ.

249. *Ardea herodias* Linn.
" " Proc. Bost. Soc. of N. H., xiv., p. 285.
Mazatlan, Grayson, Bischoff; Tres Marias, Grayson.

"Common throughout the entire year."

250. *Herodias egretta* (Gm.).
" " Proc. Bost. Soc. of N. H., xiv., p. 285.
Mazatlan, Grayson, Bischoff; Rio de Coahuana, Xantus; Tres Marias, Grayson.

"Common the entire year."

251. *Garzetta candidissima* (Gm.).
" " Proc. Bost. Soc. of N. H., xiv., p. 285.
Mazatlan, Grayson, Bischoff; Rio de Coahuana, Colima, Xantus; Tres Marias, Grayson.

252. *Demiegretta leucoprymna* (Licht.).
Mazatlan, Grayson, Bischoff; Manzanilla Bay, Xantus.

"Very common, and resident."

253. *Demiegretta rufa* (Bodd.).
Mazatlan, Grayson.

"Not an abundant species in this locality, but resident at all seasons."

254. *Florida cærulea* (Linn.).
Mazatlan, Grayson.

255. *Ardetta exilis* (Linn.).
Mazatlan, Grayson.

"Not common; specimen shot in September. I have also seen it near San Blas in November."

256. *Butorides virescens* (Linn.).
Mazatlan, Grayson; Colima, Manzanilla Bay, Xantus.

"Common at all seasons."

257. *Botaurus minor* (Gm.).
Mazatlan, Grayson.

"I have shot individuals of this species in the months of October, December and March; I am not certain of its being a summer resident as well."

258. *Tigrisoma cabanisi* Heine.
Botaurus " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 357.
Mazatlan, Grayson.

"This fine species may be met with at all seasons about the lagoons."

259. *Nyctiardea nævia* (Bodd.).
Mazatlan, Grayson; Rio de Coahuana, Xantus.

"Resident, but not abundant."

260. *Nycticherodius violaceus* (Linn.).
" " Proc. Bost. Soc. of N. H., XIV., pp. 285, 301.
Mazatlan, Grayson, Bischoff; Rio de Coahuana, Xantus; Tres Marias, Socorro, Grayson.

"Quite numerous and resident; it appears to be widely distributed throughout Mexico. It feeds chiefly upon small fish, water reptiles and crabs, for which it hunts in the night. I have, however, seen the young of the year seeking for food during the day, but the habits of the species are mainly nocturnal, and very much resemble those of the common Night Heron; it is perhaps a little less solitary, as I have often found them associating in small communities."

Fam. GRUIDÆ.

261. *Grus canadensis* Linn.
Mazatlan, Grayson.

"Make their appearance in this locality as early as the month of September, in considerable numbers, but disappear before the end of March."

Fam. RALLIDÆ.

262. *Rallus virginianus* Linn.
Mazatlan, Grayson.

"Arrives in the latter part of October, disappears in the spring; not abundant."

263. *Rallus elegans* Aud.
Mazatlan, Grayson.

264. *Aramides axillaris* Lawr.
Mazatlan, Grayson.

"The Mangrove Rail, as its name indicates, inhabits, we may say, almost exclusively the darkest recesses of the mangrove swamps, that skirt the numerous esteros, putting out from the seacoast in tropical regions. These small arms of the sea sometimes extend far inland, and often end in lakes; they are invariably fringed with the mangrove, and the immense numbers of their roots form impenetrable brakes that defy the entrance into their gloomy shades, either to the hunter or his dog.

"The first bird of this species that I was able to procure I shot in December, 1866, near San Blas. I was coming down from Los Chillos in a canoe paddled by an Indian lad; it was a little after sunrise, and we were quietly 'hugging' the dense mangrove forest that lined the narrow estero on either side, whilst other large trees over-arched the stream in many places. I was on the lookout, with my gun ready, for whatever bird might present itself suitable for my collection; I suddenly beheld something running along upon the muddy shore; beneath the shadow of the mangroves it ever and anon stopped for a moment, and went through certain curious evolutions of jerking up its short tail. I fired and killed it, but being very near, the specimen

was much injured; it proved to be very interesting as a bird hitherto unknown to me. Doubtless it will prove to be a new species in the ornithology of the country.

"Another specimen, a fine adult male, was shot by my son in April, 1867, in the mangroves that border the estero near Mazatlan; it is now in my cabinet. I examined the stomachs of both birds, in which I found small crabs and diminutive mollusca only. During the months of April and May I have, when encamped near the mangroves, heard this bird's chattering or cackling notes at different hours of the night. I had frequently heard them long before I was able to see one, and that only in the silent hours of a moonlight night. It is a constant resident of Western Mexico, and does not appear to migrate."

I was much surprised to find this species from a locality so far north, and where it is stated to be resident. Mr. Sclater (P. Z. S., 1868, p. 449) records a specimen from Belize, Honduras.

From its habits it would appear to be seldom obtained, Col. Grayson procuring but two, and considering it an undescribed species; the specimen from Mazatlan does not differ from the type which came from Venezuela.

265. *Porzana carolina* (Linn.).
Mazatlan, Grayson.

"A few seen, and specimens procured in March, 1868; found in marsh grass at Mazatlan."

266. *Porphyrio martinica* (Linn.).
Rio de Coahuana, Xantus.

267. *Gallinula galeata* Licht.
Mazatlan, Tepic, Grayson.

"Common in the winter months, arrives in November in considerable numbers. I found it breeding near Tepic, in a lagoon, in which were several pairs, together with grebes and some other water-fowl; this was in May and June."

268. *Fulica americana* Gm.
Colima, Xantus; Mazatlan, Grayson.

"Very abundant from October to May. A few breed here in summer."

Fam. PARRIDÆ.

269. *Parra gymnostoma* Wagl.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 363.
Mazatlan, Grayson; Manzanilla Bay, Zacatula River, Rio de Coahuana, Xantus.

"Quite abundant in all lagoons where water plants cover the surface of the water, upon which they walk. A constant resident, and well distributed throughout the *tierra caliente*.

"I found the nest of this bird about the middle of June, in a lagoon near Tepic; it was placed upon the prostrate branch of a tree, just touching the water, in rather an exposed position, as there seemed to be no attempt at concealment. The nest is large and well formed, of coarse grass and water-moss, deep and rounded; the eggs, three in number, were fresh, of an oval form, with reddish blotches at the larger end, the shell very thin."

Fam. ANATIDÆ.

270. *Anser gambelii* Hartl.
Mazatlan, Grayson.

"From the month of September until February in considerable flocks; appear to migrate up and down the southern gulf shores."

271. *Bernicla canadensis* var. *occidentalis* Baird.
Durango, Grayson.

"I met with this species in flocks, on the road to Durango, between the Sierra Madre mountains and the city of Durango, in the months of February and March. But I have never seen or heard of one west of the Cordilleras in this locality."

272. *Dendrocygna fulva* (Gm.).
Mazatlan, Grayson.

"There are two species of this remarkable genus found in Western Mexico, considerably resembling each other in their general appearance, as well as in their natural habits. They are both natives of the Tropics, and are quite abundant in Western Mexico, as far north as Sonora. Our present species being the most numerous in this locality, I will first treat of.

"At the conclusion of the rainy season, or the month of October, they make their appearance in the vicinity of Mazatlan, San Blas, and southward, in large flocks; inhabiting the fresh water ponds and lakes in the coast region, or *tierra caliente*, during the entire winter, or dry months, subsisting principally upon the seeds of grass and weeds, and often at night visiting the corn-fields for grain. During these months I have found them in the shallow grass-grown ponds in very large numbers, affording excellent sport to the hunter, and a delicious game for the table; their flesh is white, juicy, and feeding upon grain and seed, is free from the strong or rank flavor of most other ducks; they are rather heavy or bulky, and usually fat. They are more easy to approach than our northern species; I have shot as many as fifteen with the two discharges of my double-barrel. When only winged they are almost sure to make their escape, which their long and stout legs enables them to do, running and springing with extraordinary agility, and ultimately eluding pursuit by dodging into the grass, or nearest thicket; if the water is deep they dive, and as they rise to breathe, having only the head above water, and that concealed among the water plants, they are soon abandoned by the hunter.

"Although its geographical range is confined within the limits of the Tropics, yet this species has its seasons of periodical migrations from one part of the country to the other; during the month of April their well-known and peculiar whistle may be heard nightly as they are passing over Mazatlan in apparently large flocks, going northward. At first this phenomenon puzzled me not a little, as I well knew that they are not often found far north of the Tropics, except an occasional straggler. But I was at length enlightened as to their point of destination; by frequent enquiries of the natives, I was satisfied that they went no farther north than the Mayo and Yaqui Rivers, in Sonora, and the adjacent lakes and lagoons, where they breed. Some, however, remain and breed in the State of Sinaloa, and the adjoining localities. I found young broods near San Blas that were unable yet to fly as late as the month of November. They doubtless rear two or more broods during the season. I never have been able to discover their nest, nor have I been satisfied as to whether they nest in hollow trees, as its near ally does, or whether it forms a nest on the ground among the grass, which latter supposition, I have been informed by the natives, is the case; the natives also tell me they lay ten to fifteen pure white eggs. It inhabits the region near the seacoast, but is never met with in the sea, and very seldom in the estero or salt water lagoons, being entirely a fresh water duck."

273. *Dendrocygna autumnalis* (Linn.).
Mazatlan, Grayson, Bischoff.

"The habits of this species are so much like its preceding near ally (*D. fulva*) as to leave but little room for any additional remarks. It is, however, more nocturnal in pursuit of subsistence, visiting the dry corn-

fields during the night in great numbers, and committing considerable depredations upon the ripe corn; I have also met with them in the night time walking along the road, far from any water, picking up the grains of corn that had been dropped by the packers.

"It is more abundant in the vicinity of Mazatlan in the latter part of the dry season than its congener, but in the months of April and May they migrate during the night towards Sonora; many of them, however, remain and breed in this locality during the summer, as I have shot them in every month in the year. They breed in the hollows of large trees, and lay from twelve to fifteen eggs; the young are lowered to the ground one at a time in the mouth of the mother; after all are safely landed she then cautiously leads her young brood to the nearest water.

"This duck perches with facility on the branches of trees, and when in the corn-fields, upon the stalks, in order to reach the ears of corn. Large flocks of them spend the day on the bank of some secluded lagoon, densely bordered with woods or water-flags, also sitting among the branches of trees, not often feeding or stirring about during the day. When upon the wing they constantly utter their peculiar whistle of Pe-che-che-né, from which they have received their name from the natives. (The other species is called Durado.) I have noticed that this species seldom lights in deep water, always preferring the shallow edges, or the ground; the cause of this may be from the fear of the numerous alligators that usually infest the lagoons.

"When taken young, or the eggs hatched under the common barn-yard hen, they become very domestic without being confined; they are very watchful during the night, and, like the goose, give the alarm by their shrill whistle when any strange animal or person comes about the house. A lady of my acquaintance possessed a pair which she said were as good as the best watch dog; I also had a pair which were equally as vigilant, and very docile."

274. *Anas boschas* Linn.
Mazatlan, Grayson.

"Not abundant, and only met with in winter months."

275. *Anas obscura* Gm.
Tepic, Grayson.

"I shot many of this species near Tepic, but have not seen one in the vicinity of Mazatlan. They doubtless breed in the locality of Tepic, as I found them there in the month of June in pairs."

276. *Dafila acuta* (Linn.).
Mazatlan, Grayson; Coahuana, Xantus.

"Common throughout this region in winter months only."

277. *Nettion carolinensis* (Gm.).
Mazatlan, Grayson.

"Abundant from November to March."

278. *Querquedula discors* (Linn.).
Mazatlan, Grayson.

"A common species in this locality; a few remain throughout the summer."

279. *Querquedula cyanoptera* Vig.
Mazatlan, Grayson.

"A rather common species during the winter and spring months, but never abundant."

280. *Spatula clypeata* (Linn.).
Mazatlan, Grayson; Guayamas, Dr. Palmer.

"Very common from November to May."

281. *Chaulelasmus streperus* (Linn.).
Mazatlan, Grayson.

"Abundant from November until late in spring."

282. *Mareca americana* (Gm.).
Mazatlan, Grayson.

"This species is abundant from November until late in the spring."

283. *Aix sponsa* (Linn.).
Mazatlan, Col. Abert.

284. *Cairina moschata* (Linn.).
Mazatlan, Grayson; Rio Zacatula, Xantus.

"The wild Muscovy Duck is quite common in this locality throughout the year; breeds and perches in trees."

285. *Aytha vallisneria* (Wils.).
Mazatlan, Grayson.

"Not uncommon during the winter months."

286. *Aytha americana* Eyton.
Mazatlan, Grayson.

287. *Bucephala americana* (Bp.)
Mazatlan, Grayson.

"Common in the winter months."

In his notes Col. Grayson gives *B. barrovii* as found at Mazatlan, but not common; there is no specimen of it in his collection. and as it is strictly a northern species, I think it probable there was an error in its identification.

288. *Fulix marila* (Linn.).
Mazatlan, Grayson.

"Found in the winter months."

289. *Fulix affinis* Eyton.
Mazatlan, Grayson.

290. *Fulix collaris* (Don.).
Mazatlan, Grayson; Rio de Coahuana, Xantus.

291. *Erismatura rubida* (Wils.).
Mazatlan, Tepic, Grayson.

"But seldom seen in the vicinity of Mazatlan."

292. *Erismatura dominica* (Linn.).
Tepic, Grayson.

"I found this duck, or several pairs, about fifty in all, that frequented a small lake or lagoon near the city of Tepic in Jalisco, as late as the month of June. They were evidently desirous of breeding in that locality; the females shot by me showed enlarged ovaries. I have not met with this duck in the neighborhood of Mazatlan."

Fam. PELECANIDÆ.

293. *Pelecanus fuscus* Linn.
" " Proc. Bost. Soc. of N. H., XIV, p. 302.
Mazatlan, Grayson, Bischoff; Socorro, Grayson.

"Very abundant at all seasons."

294. *Pelecanus erythrorhynchus* Gm.
Mazatlan, Grayson.

"Occasionally seen in large flocks on Rio Mazatlan, but not resident; they do not remain long in this locality; seen in winter months."

Fam. SULIDÆ.

295. *Sula cyanops* Sundevall.
" " Proc. Bost. Soc. of N. H., XIV, p. 302.
Socorro, Grayson.

296. *Sula piscator* (Linn.).
" " Proc. Bost. Soc. of N. H., XIV, p. 302.
Mazatlan, Bischoff; Isabella Island, Grayson.

"This species breeds upon the ground near the sea beach, the nest containing usually two eggs, or young. The voice of the female is harsh, while that of the male is a shrill whistle. I never saw the male feeding the young, although he assists in incubation, and taking care of the young in the absence of the female. I found them in great numbers breeding upon the Island of Isabella, and in the latter part of April the nests contained nearly all young, or eggs ready to be hatched. One, and sometimes two, eggs in a nest, of a greenish white, and rough on the outside; inside of shell pale green. The nests were on the lower surface of the island, near the sea, many on the sea beach; the young are fed by inserting the bill down the old one's throat."

Fam. TACHYPETIDÆ.

297. *Tachypetes aquilus* Linn.
Mazatlan, Grayson, Bischoff.

"Breeds upon the Island of Isabella in large numbers; eggs, one in each nest, pure white, nearly the size of a goose egg."

Fam. GRACULIDÆ.

298 *Graculus mexicanus* Brandt.
Mazatlan, Grayson, Bischoff.

"Common at all seasons."

Fam. PLOTIDÆ.

299. *Plotus anhinga* Linn.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 362.
Mazatlan, Bischoff; Rio Mazatlan, Grayson.

"Common in the fresh water lagoons, Mazatlan River and Rio Santiago; numerous in the small river of Tepic, and Lake Chapula, near Guadalajara. In this region it is a constant resident, and builds its nest in trees, near, or over, fresh water-lagoons or streams."

Fam. PHÆTHORNIDÆ.

300. *Phœton æthereus* Linn.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 362.
Coast of Michoacan, Xantus.

"Usually found far out at sea and in the Gulf of California. Breeds on the Island of Isabel, near San Blas."

Fam. LARIDÆ.

301. *Larus delawarensis* Ord.
Mazatlan, Grayson.

"Common in winter months only."

302. *Chroicocephalus atricilla* Linn.
Mazatlan, Grayson.

303. *Chroicocephalus franklinii* (Swains.).
Mazatlan, Grayson.

"Specimens procured in December; a few others were seen in that month, but it is not common in this locality."

304. *Chroicocephalus philadelphia* (Ord.).
Mazatlan, Grayson.

"A few individuals were seen, and specimens procured, in a fresh-water lagoon near the sea-shore, March 27th, 1868. I have not seen one since."

305. *Blasipus heermanni* (Cass.).
Mazatlan, Isabella Island, Grayson.

"Not common, specimens shot on the sea beach near Mazatlan, in February and March; a winter visitant."

306. *Sterna galericulata* Licht.
" " Finsch, Abh. nat. Ver. zu Bremen, 1870, p. 359.
Mazatlan, Isabella Island, Grayson.

"Common throughout the winter months, and until the latter part of March, when they congregate on the beaches in large numbers, and in a short time disappear from this locality for their breeding grounds."

307. *Sterna maxima* Bodd.
Mazatlan, Bischoff; Isabella Island, Grayson; Guayamas, Dr. Palmer.

A few of this species are seen in the summer months, but like *S. elegans*, they congregate into flocks in March, and soon depart for their breeding places."

308. *Sterna forsteri* Nutt.
Mazatlan, Grayson.

"This species is quite abundant along the shores and esteros from October until April."

309. *Sterna superciliaris* Vieill.
Manzanilla, Xantus.

310. *Haliplana fuliginosa* var. *crissalis* Baird.
" " Proc. Bost. Soc. of N. H., XIV., pp. 285, 301.
Tres Marias, Socorro, Grayson.

311. *Hydrochelidon fissipes* (Linn.).
Mazatlan, Grayson.

"Makes its appearance in this locality in September and October; remains all the winter months."

312. *Anous stolidus* (Linn.).
Isabella Island, Grayson.

"I found this species breeding in communities on the north end of the island, upon shelving rocks, beneath the overhanging cliffs, like mud swallows. There were a great many of them in this one particular locality, and when fired at they came down in swarms over the canoe, and circled around like swallows. The nests were placed close together, but inaccessible. I, however, managed to procure one egg; it is white, with scattering brownish blotches, more numerous on the larger end, and is oval in shape. I believe but one egg is found in each nest."

313. *Rhynchops nigra* Linn.
San Blas, Grayson; Zacatula River, Xantus.

"I have observed this species during the summer months, especially near San Blas. It is not numerous, and partly nocturnal."

Fam. Procellaridæ.

There are no specimens of this family in any of the collections from Western Mexico; but two are named in Col. Grayson's list, viz.:

"Stormy Petrel (White rump)."
"Dusky Petrel — very common."

Their determination can only be arrived at by examples.

Fam. Colymbidæ.

One species of this family is on Col. Grayson's list, from the Island of Isabella, viz.: "Guillemot." There being no specimen it cannot be determined.

Fam. Podicipidæ.

314. *Podilymbus podiceps* (Linn.).
Manzanilla Bay, Xantus.

"A winter visitant, but not abundant."

315. *Podiceps auritus* var. *californicus* Heerm.
Guyamas, Dr. Palmer.

316. *Sylbeocyclus dominicus* (Linn.).
Mazatlan, Grayson.

"An abundant and common species in all fresh water ponds of this locality and Tepic, the entire year."

X. Preliminary Report on the Recent Changes of Level on the Coast of Maine: *with reference to their origin and relation to other similar changes.*[1]

By N. S. Shaler.

Introduction.

For many years there have been frequent reports of changes in the level of rocks and shoals on the coast of Maine. Generally these accounts have been of an untrustworthy nature, inasmuch as they seemed framed in palliation of some blunder of seamanship. A vessel being cast away in some well-known waters, it was natural enough for her captain to claim that the rock was not there before; or that the depth of water had greatly diminished within recent times. Every sailor who had excused his own blunders in this fashion, was naturally inclined to foster the opinion that the rocks were growing nearer the surface year by year, and without any intended deception one can easily imagine that in time a decided conviction might thus be reached. Experience in other regions has shown, however, that a prevailing opinion of this kind is apt to have some foundation. For some centuries the popular belief of the inhabitants of the Scandinavian coast concerning the changes of level of the shore, received no scientific examination: when, however, these questions were approached in a determinate fashion, it soon was made evident that the popular opinion was singularly correct, both as regards the extent and character of the movement. The following considerations, and the facts upon which they are based, result from a tolerably careful study of the record of changes along the New England coast, and from several years of summer labor.

Before giving a detailed account of the facts observable on the coast of Maine, it will be well to consider the general nature of the changes of level which have been observed in neighboring countries. I shall therefore give a brief résumé of the facts concerning elevations and depressions of shore lines in the north Atlantic section of our own continent, and those of the opposite continent of Europe. From the time that geology began to exist as a science, it has been a well-accepted fact that the surface of the dry land has been continually changing its level with reference to the sea. It is, however, among the later investigations that we begin to find anything like a careful study of the last, and therefore the most easily determinable, changes which our continents have undergone. Although by no means complete, these investigations enable us to assert, with a precision which can rarely be obtained in the science, that a great movement of elevation has taken place throughout the whole northern section of the Atlantic coast line, in the most recent times. The quantity of the vertical movement varies greatly in different places; it seems, however, to be quite certain that the elevation is generally greater as we advance towards the north.

[1] Published by permission of the Superintendent of the U. S. Coast Survey.

On our own coast it varies from a few feet, in the neighborhood of New York City, to one thousand or more on the coast of Labrador, and two or three times this amount on the Greenland coast. On the European shore this movement has not yet been proved to increase with the same regularity as we pass to the northward. Something of the kind, however, is distinctly traceable, though the local character of the phenomena is much more decided than in America. For instance, there is some proof of a depression of over a thousand feet in Wales, though northern France shows only slight evidences of very recent submergence. It will be necessary to refer to this local character of the movement in Europe, when we come to consider the cause of the submergence which took place about the time of the glacial period; for our present purpose it is only necessary to urge that the whole coast line of the northern Atlantic, with local exceptions, (which we shall see are not difficult to explain), is marked by indications which show that it is just recovering from a period of great depression. At many points the evidence is pretty clear that this movement of elevation is still in progress. It is evident, therefore, that the general character of the changes which have taken place in the immediate past in the northern Atlantic, quite harmonizes with the supposition that there is still some change in progress along the coast of North America. At least it may be worth while to give the subject a careful study. In the following section will be found the results of a journey along the coast of Maine, made with the especial intention of observing the evidence of change which might be found there, while the closing section of this Memoir will be given to the consideration of the physical causes of the changes of level of shore lines, with special reference to the great changes which ushered in the present geological period.

ON THE PHENOMENA OF ELEVATION OF THE COAST OF MAINE.

Of the three possible conditions of any coast line, elevation, stability, and depression, the former gives by far the clearest evidence of its action. Depression can only be shown by level marks observed at long intervals, or by the existence of a contour of surface of determined aerial origin beneath the surface of the water. Stability can be shown only by the obscure indications made by the long continued action of water at its point of contact with the land; extensive submerged tables of rock lying just at the height where the cutting action of the water would have left them, afford the best evidence of this condition. Elevation, however, is shown, whenever the circumstances are favorable, in a very remarkable manner. The following natural indications of this movement may be taken as valuable in the order in which they are named, the most trustworthy being given first.

1. The remains of marine animals lying embedded in stratified deposits above the level of high tide mark.

2. The existence of extensive stratified deposits of sand, gravel or mud, at points where fresh water lakes could have had nothing to do with their formation.

3. The existence of a topography not explicable on any other supposition than marine action above the level of high tides.

The first of these proofs cannot be reasonably expected to occur on all shores which have been recently elevated. Even at the present time a good deal of the shore sand and gravels making along our coast are quite wanting in animal remains; and in the glacial

period, and the changes which immediately followed it, during which times the great depression of our shores occurred, the physical influences must have been very much against the existence of animal life in any abundance. We shall therefore have to rely, in the main, upon the evidence which can be obtained from the non-fossiliferous gravels and sands of the coast.

The third sort of evidence of elevation which the shore line can give us, though not without its value in the problem before us, we shall find to hold but a subordinate place. We shall see that the duration of the subsidence on the coast of Maine was not great enough to admit of a great amount of marine work, or at least that part of the time of submergence during which the shore was bare of ice, and exposed to the wear of the sea, was not long enough to permit any great amount of erosion. How slight it was may be inferred by the fact that along nearly the whole shore the glacial scratches, which were certainly formed before the gravel beds were laid down in the stratified form which so clearly evinces the action of the seas, are still unworn, down to the water's edge.

This feature of the persistence of the glacial scratches, even to the margin of the sea, is not by any means peculiar to the coast of Maine; it is clearly seen at Newport, Rhode Island, where the scratches, which seem to have had no protection against the action of the weather, retain an admirable clearness, showing, beyond a doubt, that even in portions exposed to the full brunt of the storms, the erosion was not enough to take even a small fraction of an inch from the stone. Along the coast of Massachusetts we have the same feature distinctly shown at various points. On Cape Ann, one of the most exposed promontories of our stormy northern coast, the evidence is very clear.

Taking then the beds of stratified drift as the only acceptable and abundant evidence of depression, we must look at the question of the origin of these beds, and the possibility of their being formed by other agents than those which are at work in the sea. Some slight amount of stratification is certainly not inconsistent with the action of ice in the form of extensive sheets, especially when we consider that the plainest mark of the ice work would be that left by the water derived from the melting of the glacial mass, as the conditions changed to those which are now in action. But when the stratified drift is distributed in extensive sheets of approximately horizontal materials along the shore, all doubt of marine action may fairly be put aside.

The following account of an examination of the coast gives only those results which have an important bearing on the question in hand; many of the details which did not seem important to the conclusions have been omitted. In order to reduce the work within the limits of the time at my disposal, the study of the coast was taken up on the west shore of Penobscot Bay, and continued along the main land to the eastward, as far as Machias, Eastport, and Calais. On account of the greater range of height along this part of the coast, the opportunities for tracing the history of a change of level are decidedly better than on the coast from Portland to the Penobscot. In order to acquaint the reader with the general character of the phenomena to the southward of Maine, I shall take up the sketch of the shore at Boston, Mass.

The neighborhood of Boston, like the whole country to the southward as far as New York, is characterized by having a vast accumulation of drift materials disposed in four distinct formations, each indicating a separate stage of the changes of the glacial period, viz.: —

1. Massive drift lying in patches which show themselves to be fragments of a bed of great thickness, left by the old ice sheet as it melted away. This drift is at the base of the detrital accumulation, and is quite without traces of stratification in its most characteristic sections. A large part of the pebbles are scored by glacial scratches.

2. Terrace beds of glacial materials rudely distributed by water; the scratches generally worn away from the surface of the pebbles; the whole indicating one or more pauses in the re-elevation of the country after the passage of the glacial ice.

3. A secondary glacial series indicating a recurrence of local glaciation after the partial re-elevation of the country. These secondary glaciers about Boston occupied only the larger stream beds, being traceable in the Charles, the Mystic, and the Neponset Valleys.

4. The rearranged beds lying within a few feet of the present level, which indicate a long continued rest of the sea at or near its present place. At this level the life-bearing beds come again into prominence.

5. The extensive mud beds and marshes always colored by, and generally in the main composed of, the remains of animals and plants.

There is good reason to believe that the shore line at Boston has stood at a level some feet above its present position. Near Lynn, on the shore inside of Nahant, is a forest bed lying some feet below high-water mark, covered indeed save at the lowest water. In excavations made near Cambridge, coniferous trees have been found with their roots in place, at a foot or more beneath low-tide mark. This recent subsidence is apparently arrested, if it has not been partly overcome, by a movement in the contrary direction. All the evidence derived from the changes of the coast since the beginning of the historical period, clearly point to this conclusion.

As we go northward from Boston, as far as the Merrimac, we find essentially the same features as about Massachusetts Bay. The area of table drift which I take to indicate a period of submergence, increases as we go to the northward. The altitude to which this attains seems to become greater with the increase of area. The depths of the fiord depressions become continually greater; streams of small size occupy larger cuttings than in the country about Boston. Along a part of this stretch of shore extends a narrow island. This strip of land seems entirely composed of drift materials, and appears to be made up of the partly rearranged materials of an ancient moraine laid down during the secondary glacial period, indicated in the neighborhood of Boston by the beds marked No. 3 in the preceding list. The Merrimac would naturally have been the seat of great local glaciation during this time of renewed ice action. Draining a much larger and higher region than the Charles and the Neponset, we should naturally expect the moraine phenomena arising from this secondary ice action to be much greater here than about the mouth of the lesser streams. No evidence has yet been adduced concerning the latest and most limited movements of the shore line at the mouth of the Merrimac. All that can at present be determined is that the depression at the close of the glacial period was greater at this point than near Boston, and that the secondary glaciation which came after the restoration of the shore to very near its present level, was more extensive than at points forty miles further south.

From the mouth of the Merrimac to Portland, the increase of the *table drift* is a very marked feature in the physiognomy of the shore section. I have seen none of it below fifty feet in height; its stratification remains, however, as indistinct as about Boston. At Port-

land we have distinct evidence to show that the depression at the close of the glacial period amounted to over one hundred and fifty feet, while at Boston there is good reason to believe that it did not exceed half this amount. Along with the evidences of greater subsidence there are other facts which go to show a longer continuance of the depression. The area of the brick clays and other deposits which show the gradual silting action which must have taken place when the sea was separating the mud from the gravels of the drift is much greater in this section than in Massachusetts. Following up the valley of the river towards Lewiston, these clays and stratified sands are seen in an abundant development. All along the section from Portland northward, sections answering in general character to that shown in Fig. 1, abound. These sections unquestionably indicate something like the following history. The massive drift, the remains of which are still seen in the lower part of the section, retaining the shape in which it was dropped at the melting of the ice sheet, has first been worn away by the action of the marine currents, and afterwards covered by the finer materials torn away from some other part of the drift sheet. The imperfect stratification of the upper part of these sections suggests the idea that the force which swept the materials to their present place was of paroxysmal violence. I have treated the question of the origin of these table drifts in a report on the surface geology of the region about Massachusetts Bay, and shall not therefore repeat the matter here; the conclusion to which we seemed compelled was that the elevation of the land was likely enough of great suddenness, after the fashion of observed changes on the South American coast, and that to the sweep of the receding sea, aided, it may be, by a succession of earthquake ocean waves, we owe the rapid accumulation of these curious table drifts. The materials swept away from the coast of South America by the great waves which have swept against the shore during the last one hundred years must lie in a manner very similar to the masses we have in these rudely stratified drifts.

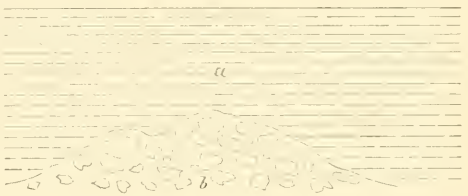


Fig. 1.

a. Stratified clays.
b. Massive drift with angular boulders quite unstratified.

In crossing from the valley of the Kennebeck to that of the Penobscot, we rise at the level of from two to three hundred feet into the region of the ordinary upland drift, such as covers a large part of Massachusetts. This deposit does not, in any regard, differ from that found further south, unless it may be in the greater size of the fragments which sometimes are found in the mass. I am tempted to believe, from the great variety of the materials found together, that on the whole the transportation from great distances is much more common here than in Massachusetts.

On the Penobscot Bay the quantity of drift material, and its disposition, differs somewhat from what we find on the Kennebeck. The mass of the detrital matter seems greater, and the amount of silt beds much less than near Portland. At Belfast, where the drift is seen to considerable advantage, the following points are observed. The principal channel of the bay, and the minor streams which fall into it, are both quite free from evidences of the local secondary glaciation, such as we found in the valleys of the streams near Boston. The reason for this is easily found without supposing that the secondary glaciers were want-

ing here. In the neighborhood of Boston these local glaciers left their moraines at a few feet above the sea level. When they retreated from this position they wasted rapidly, leaving no distinct moraines in the upper part of the river basins. It is true that about Mount Wachusett, at heights of over seven hundred feet above the sea, these ice marks are found again, but the changes required to carry the ice in the valleys back from the sea to heights of near one thousand feet must have taken place with great rapidity, so that no moraines were left. During the return of the ice the glaciers would have pushed their moraines far beyond the shore line on this part of our coast, so that they would have soon been wasted away by the sea. None of the elevations near here give favorable points for observation concerning the later stages of the ice retreat. Among the Camden Hills, however, I found several traces of local glaciation, going to show that the ice lingered there as it did on the flanks of Wachusett, only at a somewhat lower level; the point of arrest in the former locality seeming to be about two hundred feet lower than in the Massachusetts Hills. This is explained by the more northerly position of this region.

The drift at Belfast lies in a nearly unbroken slope, extending from a point about two hundred and fifty feet above the water down to near the tide mark. There can be little doubt that the sheet of drift was once of quite uniform thickness over the floor of the Bay and surrounding country. The action of the sea during the time of depression at the close of the glacial period, leveled off the surface and partially stratified the materials. The work of rearrangement of a glacial mass by water action, can only go on at the period of contact of sea and land. Under the influence of the strong tides which sweep the shore, pebbles as large as walnuts can be carried for great distances down descending slopes, but larger masses cannot be moved except by the agency of the waves. The work began at the point of greatest depression, when the sea line was about two hundred and fifty feet higher than at present, and has been continued step by step as the sea retreated down the long slope. Naturally the action of the weather has done something to obliterate the successive stages of this great movement of the sea, but enough remains to enable us to make some important general conclusions concerning the way in which the change came about. In the first place it is to be noticed that there are nothing like distinct terraces on this drift slope, which would justify us in supposing that the elevation took place very steadily and rapidly without the long pauses which would be required to make terrace marks strong enough to endure. The amount of aerial erosion which has acted upon this partly arranged drift, is seemingly about equal at all levels from the base to the summit of the slope. Without attaching very much importance to this sort of evidence, it may fairly entitle us to suspect that the time occupied in the change which carried the sea through a vertical movement of two hundred and fifty feet was relatively very short indeed. It is quite clear that the time required to cut the scarp which marks the present shore has never been given to the work of terrace making at any point between the point of greatest depression and the present shore line.

As I shall discuss the general relations between the glacial action and the hydrography of the State of Maine in another part of this report, it will not be necessary at this point to give any study to the form of the great basin of Penobscot Bay. I therefore pass at once to the east side of the Bay.

In the neighborhood of Castine, and along the shore to the southward, the deposit of drift is much thinner than in the neighborhood of Belfast. This is clearly due to the dif-

ference in the character of the underlying rock which is much less easily riven by the ice action than the rock on the east side of the Bay. This shore therefore wants the distinct inclined plane of detritus, which we have described as occurring on the western side.

The Megobben Reach offers us a curious case of a continuous valley lying in a position where its formation cannot well be accounted for by the excavating character of ice action. From certain indications derived from the form of the "roches moutonées" in this reach of water, I was somewhat inclined to think that a part of the great stream which poured from the Penobscot Bay during the glacial period, was turned from its more southern course to pass through this valley. From the general character of the valley, however, I am now inclined to consider it as marking the place of a great east and west fault line, which has been developed by the ice action. Along its whole shore the drift lies in thin masses, being much less developed than in the country to the west of the Penobscot. The reason for this is likely to be found in the hard nature of the rock lying to the north. Moreover, the transporting power as affecting the distance whence the detritus could have been derived would have been greater in the valley region of the Penobscot than on this shore where the gathering together of ice streams did not occur.

At Sedgwick there occurs a considerable indentation in the shore to the northward, marking the point where the harder syenitic is replaced by a soft serpentinous rock, in which the pebble-armed ice managed to make a deeper cut. The barren hills at this point and to the eastward as far as the village of Brookline, are denuded of all the small drift, nothing of the glacial debris being left except the larger boulders. This stripping, which I am compelled to refer to the action of the sea during the period of depression, extends from near the water line to at least two hundred and fifty feet above the sea. Many of the heaps of boulders are wedged together as if they had been strongly beaten by wave action. A part of the deep waters which surround Mount Desert lie between Brookline and that Island; the small islands which dot its surface have but little drift upon them, and this in no way characteristic. The insular masses which lie to the southward of Megobben Reach were not visited by me on account of severe weather, which rendered it difficult to pass the intervening waters. So far as seen they had the same character as the rocks to the eastward, there being comparatively little drift on their faces. Report has recently come to me of the discovery on Deer Isle, at the height of about two hundred feet above the sea, of a mass of marine shells of the same age as the beds at Portland.

On the Island of Mount Desert the evidences of great subsidence during the glacial period are few and inconspicuous. The reason for this is probably to be found in the fact that owing to the great height of the hills the secondary glaciation was quite strong and long continued, and resulted in sweeping away to the seaward the product of the erosion during the principal ice time. The re-elevation of the island was probably complete, or nearly so, before the ice ceased to pour from the hills into the sea. It is only close to high water mark, say within twenty or thirty feet or so, that there are any distinct signs of stratification in the glacial material. The evidence of the existence of extensive local glaciers is very perfect. The numerous valleys leading from the hills have all more or less distinct moraine heaps along their course. The valley of Great Pond is dammed to the southward by a moraine mass, having a height of about one hundred feet above the water. I have industriously searched the flanks of the Mount Desert hills for any trace of terraces, but have failed to find them even in their most obscure form.

East of Mount Desert the shore, as seen from the sea, presents essentially the same conditions of erratic phenomena. The coating of drift is quite thin, and seems to be altogether of the secondary glacial time. At Milbridge the detrital sheet is again rather thicker, but in character and origin does not differ particularly from that at Mt. Desert, except that there are some signs of a table of detritus at the height of about one hundred feet above the water. Most of the small rocky isles which make up the outer fringe of the fiord zone, between Milbridge and Machiasport, are bare of drift, or nearly so, showing the action of ocean waves for at least one hundred feet above the present level of the sea. The character of the drift remains unchanged along this part of the coast. The remains of the original glacial action, or that produced by the first stage of the glacial period, are rare, if indeed they exist at all. Most of the drift material seems to have been reworked during the second coming of the ice, when the glaciation, though insufficient to produce a great wear upon the rocks, or to accumulate much detritus, yet served to efface or render illegible the record made by the far greater ice time which preceded it. Between Machiasport and Eastport the drift materials were narrowly examined: they seem to belong altogether to the second stage of the ice action. The only peculiar features observable are connected with some thin beds of brick clays, which seem to mark the persistence of the subsidence after the passage of the ice from the coast in its retreat. The country back of this section of the coast has comparatively little height, so it is not improbable that the ice was less strongly urged to the seaward at this point than in the region to the westward. This may have caused the ice to disappear here sometime before it did on the other parts of the coast.

The intensity of the ice action, which had evidently suffered some abatement in the section between Machiasport and Eastport, as is shown by the disappearance of the fiord character in this part of the shore, is again augmented in the immediate vicinity of the latter point. The harbor of Eastport, though a typical specimen of fiord structure, is almost destitute of glacial waste. Area for area it has not the tenth part of the detritus we find in Boston Harbor, though the proportionate erosion has been more than as great. The channels between the islands are far deeper than those found in Massachusetts Bay, indicating a cutting agent much more active. Here, too, the ice, having kept its place upon the rocks for some time after the re-elevation of the shore, there is little evidence of recent elevation. Some few faintly indicated terraces lying at a height of ten or fifteen feet above the sea, seem to show that the last ten feet of the lift may have been effected after the re-elevation of the shore. All the drift material appears to have been derived from the immediate neighborhood of the shore line: there is none which we are required to refer to points far in the interior. Here, as elsewhere, it must not be hastily inferred that the glacial period did not effect the transportation of materials from great distances. We must reconcile the facts as we find them, with what we may observe at other points where distant transportation is most unequivocally proven.[1] This can best be done by supposing that the secondary glaciation swept away the debris left by the first, and allowed only the product of its relatively feeble erosion to attest the presence of glacial conditions.

From Eastport northward, there is a gradual change in the character of the drift material which is hard to explain. The beds of gravel nearly disappear, and in their place come

[1] In the Ohio Valley, as far south as 38° N. L., we have materials which have come from a region at least six hundred miles north of that point by the agency of ice.

considerable deposits of clay, extending to rather over one hundred feet above the low water mark. The stratification of the clay is quite evident, and affords the most unquestionable proof of subsidence. It is obviously difficult to reconcile the ideas of a coast covered with ice about Eastport, but becoming more and more freed as we pass to the northward towards Calais. Such irregularities seem, however, to exist in the region where similar conditions continue to the present day, as upon the shores of Greenland and Spitzbergen; the ice attaining the sea at parts of the shore, and leaving great stretches quite uncovered. There is something in the arrangement of the interior country along this shore which may have affected the peculiar distribution of the ice. The considerable chain of lakes lying to the north of Eastport marks a valley which develops on that part of the shore, and may have guided a great mass of ice from the interior to the coast, in such a fashion as to sweep the shore from Machias to Eastport, while leaving the west coast of Passamaquoddy Bay quite uncovered, and free to receive the sediment of the sea during the time of depression.

Near Calais there are some, though rather faint, traces of local moraines. It is highly probable that during the closing stages of the ice time this valley, from Calais north, had its local glacier. For some miles above Calais the clays keep their place in the river valley, but of their development in this direction I have no information. From Calais to McAdam Junction, and thence to Bangor, the view of the drift phenomena was hastily gained from the railway train. The following observations on the distribution of the erratic materials along this route may not be without value.

The underlying rock in the section between Calais and McAdam, has been planed down until there are only slight reliefs derived from the bed rock. The amount of ice action indicated in this section seems greater than that of any part of the coast of Maine, and is owing to the fact that the materials composing the bed rock are of far more uniform hardness. It is probable that the vast accumulations of the St. Lawrence basin, which have forced their way in part to the east and southeast, forming with their debris the great masses of the Banks of Newfoundland, did not give complete relief to this ice sheet; a part found its way over the low barrier at the head of the Bay of Fundy, and swept its shores with a stronger ice stream than that which worked on the coast of Maine. The secondary ice period was sufficiently strong in this section to give us moraine matter almost as abundant as the great ice time in Massachusetts. For the first ten miles from the sea there are extensive clay beds. After that we come upon ordinary boulder drift. The distribution of this debris is quite unlike that in the regions to the southward. Over the whole surface is a rather thin sheet of pebbles, somewhat affected by water action at various points; strongly marked moraines, extending in an east and west direction, show the action of the retreating ice. This structure is best seen near Barlow's Mills, where the ridges seem quite continuous, having a height of about fifty feet, a horizontal section of three hundred feet or more. The intervals between several of these ridges was not over some hundreds of yards.

From McAdam to the Saint Croix, the surface slopes gently downward, with only slight indications of local moraines. The valley of the St. Croix has a singular want of boundaries. At the point where the railroad crosses there is scarcely a trace of containing walls. The stream evidently has a fair amount of cutting power, and has been at work since an early geological time, so that we must suppose that it has been able to excavate the usual amount of material in forming its valley. We can best account for the present want of

relief by supposing that the glacial erosion has destroyed the relief which the flowing water had made. From the St. Croix to the Penobscot, there is little variety in the drift marks; at Mattawamkeag the country is level, with a rather thin coating of drift, most confusedly arranged, there being nothing like distinct moraines at the head of the last named stream. The valley is scarcely better defined than that of the St. Croix. In the table country of Kentucky or Tennessee, where the rivers have about the same cutting power as here, the channel section would be several times as deep. This feature of excavation increases as we follow the Penobscot to the southward, and with the deepened valley comes a greater distinctness in the order of the glacial debris. Near Mattawamkeag it is difficult to recognize anything like distinct moraines, but when we get within thirty miles of Bangor these remains become more and more distinct. Close to the latter town these terminal heaps are very well marked. The fact seems to be that the retreating glacier had no local organization in the upper part of the valley, while its independence was marked about Bangor. As seen at a glance, the section north of Bangor presents no evidences of having been below the level of the sea at the close of the glacial period. As in the localities previously discussed, this is to be accounted for on the supposition that the ice retained its place in sufficient thickness to bar the access of the sea during the period of great submergence.

In recapitulation of the evidence afforded by the detrital beds of this section of the Atlantic sea board, we have the following points which are worthy of notice.

1. The depression of the land at the close of the first division of the glacial period, a depression which seemed to increase in amount as we went from the southern to the more northern regions.

2. The return of the ice in the shape of a set of local glaciers which covered the shore at Mt. Desert, and along most of the territory, at least as far as New Brunswick, persisting until the final re-elevation of the land to near its present level.

From the inspection of the coast of Maine alone it is not possible for us to form any satisfactory judgment as to the time which has elapsed since the passage of this secondary ice sheet. The evidence obtained on other parts of the coast of the North Atlantic, and among the mountains of Europe, points to the conclusion, which is very general in its way, that a period of at least ten thousand years must have elapsed since this great change took place. This point will be seen to have an important bearing on the matter of the re-elevation of the shore, when this comes to be considered in the final section of this report.

THE EXCAVATION OF THE ICE TIME.

In reports on the glacial history of Narragansett and Massachusetts Bays,[1] I have considered somewhat in detail the action of an ice sheet working over a surface of irregular hardness. I shall not repeat here the matter discussed in those papers, but only recapitulate briefly the general conclusions which are necessary for our present inquiry. The following propositions I regard as established.

1. That the fiord zone results from the irregular wearing of the rock surface traversed by the glacial sheet; the whole of the surface within the glacial tract wherever the differ-

[1] The report on Massachusetts Bay is not yet published.

ences in hardness are great, has been marked by the peculiar corrugation which, when made apparent by the level of the sea, as on the coast line, comes into peculiar prominence.

2. The wearing has been determined by the following additional circumstances. (A.) The velocity of the stream. (B.) Its depth. (C.) The angle of declivity, and (D.) the arming of the ice sheet at its bottom with pebbles of sufficient hardness to have a strong cutting power.

3. As an adjunct to the ice action,— the subglacial streams; these doubtless existed then, as they now exist in Greenland, and must have coöperated in many cases with considerable effect in the formation of the deeper cuts of the ice.

4. There is an important conclusion, a corollary to the preceding propositions, that the deeper any cut becomes through the action of glacial movement the more rapid the wear. The accumulation of the ice in the valleys tends to relieve the weight acting upon the hill tops, and thus magnifies the erosion on the low grounds at the expense of the wear of the higher surfaces. Thus it is seen that while ice in some of its conditions of action is indeed a planing agent, it is not strictly correct to regard it as necessarily or even generally an agent which acts against existing reliefs.

So far as I have been able to see, the excavations which cut up the shore of Maine present no difficulties which demand especial explanation. All the great fiord-cut shores of the world are excavated in highly metamorphosed materials. It is a fact, that metamorphosed rocks, especially the series which is affiliated with granite, vary far more in composition than any of the unchanged sedimentary beds. In most cases this great variety of structure depends upon the action of the penetrated waters charged under varied conditions of heat and pressure with the chemical agents of change. Fissures which gave passage to these streams have naturally had their borders far more completely changed than the other parts of the mass. Other agents have coöperated to localize the characters of our metamorphosed rocks, making them as unlike in their horizontal sections as our unchanged rocks are uniform in this direction. Chief among these is the contorting action to which they have been subjected, which by bringing different beds to the surface in their narrow areas, has powerfully contributed to the diversification of the hardness of the surface.

The evidences of great excavation along the coast of Maine are invariably associated with either of the two following circumstances, the previous existence of great drainage channels, obviously determined as regards position and direction by running water, or the presence of great obstacles which have, by partly diverting the ice stream, concentrated its wear in narrower limits. The truth of the first of these propositions is evident to any one who will take the principal rivers of Maine, examine their drainage basins, and observe their dependence on features which could only have had a value with reference to the action of fluid water. If the direction of the river systems had been in any way determined by the ice action, they would have been very differently arranged from what they are now. It is evident that they are the work of water acting in its fluid form, and that the action of ice has been limited to a certain amount of broadening and deepening the channels it already found in existence.

The exceptions to this general rule are found in those cases where the presence of an obstacle of great height has interfered with, or where the difference in hardness of the materials flowed over has greatly modified, the cutting action of the ice. At Mount Desert, for example, we have a great mass of high land extending in a general northeast and

southwest direction, opposing the trend of the ice current which came from the north by west in a very direct fashion. It will be seen, however, that the tendency has been to deflect the lower part of the ice stream to the southwest, a part, however, passing around to the east of the chain of hills, and a part pouring through the deep valleys of Somes' Sound and Great Pond. The result of this deflecting action has been to deepen the channel on the west of Mount Desert until it is by far the most profound of all the fiords on the coast of Maine. By the less considerable ice stream which was turned into Frenchman Bay, that great though relatively shallower excavation was formed.

Wherever the ice moving over a plane surface is arrested by any such partially surmountable obstacle as the hills of Mount Desert, the result of the effort to mount the barrier is an increase of wear at the base, at the point where the change of direction is brought about. To this action we doubtless owe the fact that all the elevated points along this coast are separated from the main land by strips of deep water. It may also be noticed on the main land that mountain masses, which have interposed as barriers to the movement of the ice, have had the region to the north of their bases much more cut away than the southern segment. Many of these barriers have extensive lakes to the immediate north. This is conspicuously the case in Wachusett, Mass., and is seen in many other points in New England. Even in those cases where the map shows no lake basin, it will often be found that extensive swamp areas mark the position of lake basins which have been filled up since the glacial period. By this filling up more than two-thirds of the area of lake surface existing in southern New England at the close of the glacial period has been destroyed.

The peninsula of Nova Scotia probably turned the ice current which came down the St. Lawrence, so that it sent a good part of its stream over the low col at the head of the Bay of Fundy. This stream would have tended greatly to increase the excavation of that singular arm of the sea, and may perhaps, in part at least, account for the prodigious depth of the central abyss recently discovered there by the explorers of the United States Coast Survey.

This is hardly the place in which to undertake any inquiry into the physical history of the Gulf of St. Lawrence. We may, however, call attention to the fact that this great basin is in all essential aspects comparable to the Great Lakes which lie at the upper part of the valley, and must be explained in the same manner. Being at once at the end of a great river system and on the sea board, it must have been swept by a far stronger ice stream than the upper and more interior basins. If, as it seems most reasonable to believe, the great lakes, from Superior to Ontario, have been dug out by ice action, then we must regard the Gulf of St. Lawrence as the product of the same forces, more gigantic in proportion to the greater mass of the wearing agent.

While we find ourselves forced to attribute so much work to the action of ice upon this part of our shore, it must necessarily be asked how far the erosion and transportation has been accomplished by the ice-time which has just passed away. All the indications of glacial action being essentially superficial, its marks are in a peculiar degree liable to the destruction which in a greater or less degree awaits all geological records. We have seen how the secondary period of the last glacial time, though it brought but a thin sheet of ice over the shore on the eastern coast of Maine, still swept away from that section all the great evidences of previous ice work which, in the more southern district of Massachusetts

form such prominent features. So it is evident that the marks of glacial work coming from a time anterior to the last ice period, however conspicuous in their day, would have been in the main destroyed by the succeeding period. I cannot undertake to give a final answer in the matter of the time at which the excavating work along the coast of Maine was accomplished. Certain circumstances incline me, however, to the opinion that the ice work was in a great degree done by glacial action anterior to the last glacial period. Of these the most important is the following.

If we examine closely the shore line where it is drawn along the rocky part of our coast, say from Massachusetts Bay to Eastport, we find that everywhere there is a steep escarpment bounding the land, which shows in every feature the work of the sea. The general relation of this escarpment to the adjoining country is shown in Fig. 2. There can be no doubt that this cut represents the wearing of the sea acting continuously, and for great periods, at the same, or near the same, level. But it is evident that the last glacial period found the shore in much the same form as at present, for, except when the rock is very crumbly, or exposed to the severest beat of the waves, it is covered with the scoring of the ice sheet. Now if the wearing brought about during the glacial period did not exceed the few feet which would have been required to erase the old shore line, it is evident it could not have sufficed to dig out the great fiords along which that shore is traced. Yet the valleys of the fiord section are as clear and sufficient evidence of ice work as the glacial scratches themselves, and must be explained by the same agent. Thus it is seen, beyond reasonable doubt, that between the time when the shore was formed and the present day, the ice action which has occurred was relatively only slight, and could not have accomplished the greatest part of the ice work indicated by the topography of the region. At first sight it would seem as if we might find an explanation by supposing that the shore had been excavated between the first disappearance of the ice and the return of the glaciers at the second stage of the period. But besides the evident difficulty of the length of time between the two phases of the ice period which this hypothesis requires — a time which, measured by the rate of cutting of the waves, must have been several times as great as that which can be called post-glacial — there is the fact that in Massachusetts the secondary glacial period did not make any continuous sheet of ice whatever, but only local streams leading from the high land toward the shore in the principal river valleys. Even in nearly the southernmost country where the ice came in a sheet to the shore, in the valley of Narragansett Bay, we have the same glaciated coast, and the same sea beach scored and grooved by the ice. It thus becomes evident that the topography of this country is due to antecedent glacial periods having an effect far exceeding in aggregate amount the work of the last of the series. Having proven more than one glacial period, it is easily seen that it becomes probable that this work has been done by a number of successive ice-times rather than by any one great period of this character. This view of the duration and severity of the ice-time is in perfect accordance with what is known from other sources concerning the condition of that time. Many students of the question of the origin and antiquity of man

Fig. 2.

a. The escarpment made by the action of the sea generally scored by the ice of the last glacial time.
s. Sea level.

are now convinced that he antedated the last or generally accepted glacial period. Many of our existing land animals seem to have survived that great change. It is difficult to see how these things would be possible if the ice action had continued long enough to mould the whole topography of the circumpolar regions down to the parallel of 40°.

I have elsewhere discussed the question of the origin of glacial action, and shall not repeat the matter here, except to indicate summarily the opinions to which its consideration seemed to lead. These were briefly as follows: —

Glacial action, such as is indicated by the records of the last ice period, requires us to suppose an intensification of evaporation over all the oceanic areas between 40° north and south of the Equator. This increased evaporation could only be brought about by an increase in the heat of the surface of the earth causing an enhancement of the supply of vapor for condensation. Of all the possible sources of increased heat the following are the only ones which have been suggested which deserve consideration. 1. Change in the attitude of the land and sea to each other. 2. Change in the temperature of celestial space through which our solar system is moving. 3. Change in the excentricity of the earth's orbit in connection with the precession of the equinoxes. Each of these hypotheses has proved in the end unsatisfactory. We therefore were driven to the hypothesis, which is borne out by many considerations, that the sun is a source of varying heat; that it is in fact a variable star. The sudden increment of its heat by one-half would make the inter-tropical region the seat of intense evaporation, and the cloud-wrapped polar regions the seat of excessive precipitation, while the counter-trades, or return upper currents of air, would have their carrying power much enhanced by the greater activity of the trade wind system, consequent on the increase in the difference between the temperature of the equatorial and polar regions.

Looking upon our sun as a variable star, we get a basis for recurrent change, and can conceive the physical and vital phenomena of our planet moving in accord with the changes in that source of nearly all the physical and vital energy of the earth's surface. Some evidence has already been obtained of the following glacial periods: —

1. In the Cambrian, about the zone of *Paradoxides Harlani*.
2. At the close of the horizon of the Cincinnati group.
3. In the time immediately antecedent to the heavier coal measures of the carboniferous period.
4. In the trias. Evidence of the occurrence of glaciers in this period has been found in South Africa as well as Europe.
5. In the tertiary (probably three periods).

When we consider the extreme liability of such action as glaciation to be destroyed by subsequent agents, it becomes clear that these few periods, determined at the very outset of the research into the history of this agent, must be only a small part of the successive periods of similar change. It is also evident that the recurrence of successive glacial periods must have a most important influence upon the course of life; forcing great migrations, and effecting great changes in the whole character of the conditions of existence. It is not my purpose at this time to consider the evidence which can be brought from other regions to show the immediate value of these changes; and I can only indicate that the horizons of all our conglomerates are horizons where great changes have been effected even in the marine life, which is likely to have been less influenced by the change than the life of

the land areas. Moreover, we may hope to get, through the study of these relics of the past glacial action, a means of determining the identity of formations at points remote from each other. If there should, for example, be evidence that at various points on the earth's surface rocks of supposed triassic age, as determined by their fossil contents, are associated with distinct evidences of glacial action, we may feel that the identification of age is more exact by far than it can be made on the evidence derived from fossils alone. That similar organic forms can continue to exist in one region long after they have been extinguished in another, is a fact so well recognized as to need no proof; but a glacial period, we are entitled to believe, must have been simultaneous, at least throughout one hemisphere, probably over both, and may therefore give with certain lessened risks of error, a means of determining identity of time in regions remote from each other.

ON THE CAUSE OF DEPRESSION IN THE GLACIAL PERIOD.

That there is a necessary connection between the accumulation of great masses of ice, such as the glacial periods brought upon the surface of the circumpolar regions, and the depression of those regions, is a point most easily demonstrated. Over the whole of the shore of the North Atlantic the evidence is complete; at the southernmost point where the glacial action has been observed, we find slight evidences of subsidence. This increases steadily, though irregularly, as we go northward, until we come to the highest latitudes where civilized man has penetrated, where we have evidences of subsidence amounting to two thousand feet or more. The only hypothesis as yet advanced to account for this irregular movement, is that of which Adhémar was the originator.

The accumulation of a great weight of ice at either pole in succession, would result in the displacement of the centre of gravity of the earth, which would be drawn the nearer to the pole where the accumulation took place. The result of this change upon the altitude of the sea would be very great. The water being free to obey the changed conditions would rearrange itself with reference to the new centre of attraction. The result would be the deepening of the sea by the amount of the displacement of the centre of gravity about the pole where the ice accumulated. That such a result is in good degree a necessary consequence of the accumulation of masses of ice about either one or the other pole, is easily believed. But there is every reason to suspect that the conditions were not fulfilled during the last glacial period. The observations of Darwin, and more recently, and more especially, of Agassiz, have shown that the southern extremity of South America bears marks of as recent and extensive glaciation as the Northern Hemisphere. Until it is proven to the contrary by evidence which has not been seen, we must suppose that the glaciation in the two hemispheres was simultaneous. If this be the case, the idea of a displacement of the centre of gravity is no longer so available as an explanation; for although the tendency to accumulate the seas about the poles would exist in a very diminished way under this condition, its amount would not be sufficient to account for the phenomena of depression. Moreover, any result of this kind would probably be more than compensated by the substrata of material from the sea, and the consequent reduction of its depth. If we suppose both hemispheres laden with ice down to the parallel of 45°, then the thickness to be on the average one mile, we shall have subtracted from the ocean water enough to lower its depth by over half a mile of altitude. Something of this would be compensated

by the attraction of the mass of ice about either pole; but it is clear that inasmuch as the seas do not rise under the influence of the masses of the continents against which they rest, at least more than a trifling amount, so the water could not rise against the polar ice caps to any great height. The double polar ice cap, even were it a mile thick, could not affect the gravitation of the sea more than the high lands of Western South America. Moreover, the fact that in high northern countries some time elapsed after the disappearance of the ice cap before the re-emergence of the land took place, while on the theory of disturbed gravitation it should have disappeared *pari passu* with the waning of the ice, is a strong argument against the sufficiency of this explanation. Probably the most insuperable objection which can be made against this hypothesis of depression through a change of the centre of gravity arising from the magnitude of the ice sheet, is found in the fact that the depression does not increase with regularity throughout the whole of the Northern Hemisphere, which it should have done if this view be correct. The increase from a few feet (not exceeding fifty) along Long Island Sound to three hundred on the coast of Maine, is excessive. This rate, if kept up, as it must have been if this hypothesis be true, would have made the depression at the poles many miles of depth.

In view of these arguments I find myself compelled to abandon this view concerning the origin of the glacial depression. In seeking another explanation of the phenomenon, I have endeavored to arrive at something which should be easily connected with the general facts of continental and other mass movements of the earth's crust. In pursuing this object the following opinions have been forced upon me.

The constant movements of sea and land show clearly that the surface of the earth and the solid matter, for a considerable depth, are subject to movements which vary much in direction and intensity. At first sight, however, it would seem as if this variety of movement was far more considerable than it is in fact. The following considerations will serve to limit the phenomena in the range of its action in an important way.

As the sea is the region of constant deposition, and the land of constant erosion, there must be in the long run quite constant upward movement of the land areas and depression of the floors of earth beneath the seas. For instance, the region of the Ohio valley was near the sea level in the silurian and carboniferous times, and is a few hundred feet above it at the present day, notwithstanding the constant erosion which has affected it nearly ever since. We cannot reasonably reckon the time which has elapsed since the coal period at less than twenty million years. Now the rate of wear on this region, as shown by the discharge through the Mississippi River, will carry away about one foot in seven thousand years. This may be reduced to one foot in ten thousand years, if we would keep within bounds. But even this slow rate will require a steady rise of at least twenty-five hundred feet since the close of the carboniferous period, relatively a very modern period. Further to the northward, the Laurentian Hills, judged by their age, must have lost several times as much height, even supposing they waste only at the rate of the plain, which is far below the south. This class of facts entitles us to suppose that the lands are, on the whole, constantly rising. On the other hand, all the known facts, such as the continuous deposition of strata to the amount of thousands of feet in waters always shallow, the increasing evidence of ancient zoological barriers in the sea, under circumstances which require us to suppose that depth of water was the obstacle to the exchange of life; and other facts which cannot be

succinctly stated, give us evidence of the truth of the natural supposition that concurrent with the rise of the land there has been a constant increase in the depth of the sea.

If we try, however, to reduce all great changes of level to the two movements, sinking of the sea and rising of the land, we are met by the difficulty, which will suggest itself to all geologists, that the sea and land have in many regions changed places in alternation. It seems to me, however, that this difficulty is in a great measure overcome by the careful study of the necessary conditions of the movement. In diagrams Nos. 3, 4 and 5, we have represented the line from the centre of any sea to the interior of any continental area. Assuming that the constant tendency of the movements is to depress the seaward part of this section and lift the landward part, we have to notice that there must be a fulcrum point, or point of rotation of the movement. This point may occupy either of three relations in reference to the sea. It may be to the seaward of the shore; it may fall at the shore line, or it may lie to the landward of the shore. Supposing the sea floor to be constantly sinking, and the land constantly rising, it is evident that in the first of these suppositions the land would continually gain on the sea; in the second case, great changes might take place without any effect on the position of the shore; while in the third case the sea would seem to gain on the land. The fact that in most of the land areas where we knew the geology well enough to form an opinion on the matter, there are centres of ancient upheaval about which the oscillations of level have taken place,

In the diagrams 3 and 4, similar letters denote corresponding points.

In figures 3 and 4, the straight lines A B, A′ B′, are diagrammatic expressions for sections extending across the shore. For convenience of delineation, the action of the movement of the small segments of the crust represented is supposed to be like that of a rigid bar.

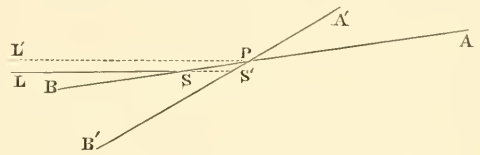


Fig. 3.

In Fig. 3, the pivot point, P, is to the landward of the shore, S, the line A B indicating the surface of the continent near the coast. Let the depression of the sea floor and the elevation of the land go on until the continental surface is in the position indicated by the lines A′ B′, and the shore will be removed to the point S′, and the sea gains. S L, indicates the sea level. If we suppose, however, that the dotted line P L′, denotes the sea level, then the pivot point will fall just at the shore line, and all the changes in the position of the line A B will not affect the position of the water lines.

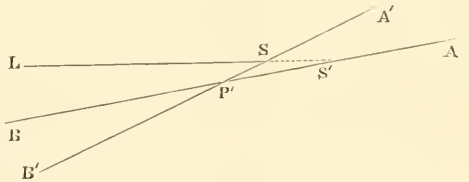


Fig. 4.

In Fig. 4, the pivot point is the seaward of the shore line A B, indicating the original position of the continental surface, and A′ B′, the position of the change. Inspection will show that in this diagram the change has caused the shore to move seaward, and the land gains.

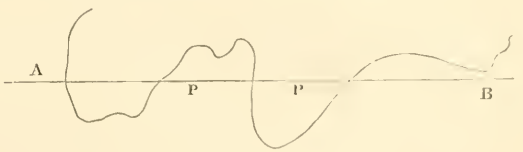


Fig. 5.

Fig. 5 represents a shore line with an axis of rotation, A B, cutting it in such a manner that the points P and P′ may be taken for the pivot points of the diagrams 3 and 4, respectively. All that portion of the shore line above the straight line would be sinking; all below, rising.

is much in favor of this theory of the changes of sea and land. For our present purpose it is not necessary to argue this question in all its phases, it is enough that it enables us to coördinate the changes of the sea and land, and so far to aid us in the conception of the instability of the equilibrium of the crust which is one of the most important facts brought to light by the study of the geological record. The constant changes in the position of the fulcrum point of the movement of sea and land, show that the position of this point, with reference to the whole line, is a matter liable to constant change. In the determination of the position of this fulcrum we may be reasonably certain that whatever the source of the force which brings about the upheaval and subsidence, the matter of weight must have a certain value. Physicists who have attentively considered the question of the origin of the continental folds and ocean furrows, are quite in accord in considering them as folds of the earth's crust, or, to keep clear of assumptions, let us say the outermost part of the earth, which has been compelled to adapt itself to a diminished interior. Without pretending to claim this conclusion to be so well founded as to put an end to controversy, we may use it to complete our conception of the relation of forces to the section from the interior of the continent to the centre of the sea. It will be evident that this section must have its present place determined by two main factors, the energy of the uplifting force and that of the restraining weight. If the amount of this weight at particular points can be made to vary considerably, the whole effect of the movement may be materially changed. A careful consideration of the accompanying diagram will show that a change in the position of the point of rotation or fulcrum of the section will completely alter the result of the movement. When the pivot point is just at the shore line, a great deal of sinking of the sea floor and elevation of the centre of the continent may take place without affecting the relations of sea and land. When the pivot point is to the land side of the shore, then the movement will make the sea appear to gain on the land; when the pivot is to the seaward of the shore, then the land will gain. Elsewhere I have followed these considerations in a more detailed fashion with special reference to the question of the origin of continents. The conclusion is, however, so evident that it is hardly necessary to trace the whole matter here.

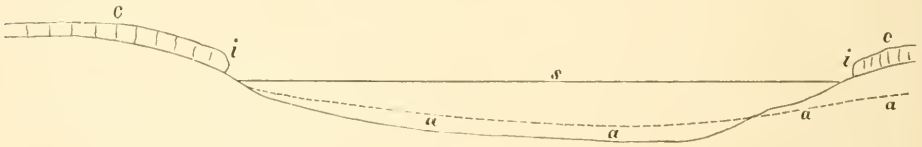


Fig. 6.

The dotted line, *a*, *a*, *a*, *a*, indicates the change of position of the surface after the ice caps have been formed. *c*, Continents. *i*, ice sheet. *s*, sea level.

It is very important to notice, however, that in the case of a rigid mass, such as we suppose the crust to be, supported on material having sufficient mobility to give way under strain, much as a fluid would do, then the imposition of any weight upon one extremity of a given section, such as is shown in Fig. 6, would necessarily produce a change in the position of the pivot point. Now in the ice accumulation of the glacial period we have just such a change of weight as would be likely to bring about considerable effects of this kind. A great mass of water is taken from the sea and heaped to the depth of a mile or more

upon the land. A mile in depth of ice weighs about as much as half a mile of ordinary rock, so that by covering the continent of North America with a deposit of this kind we more than double its altitude above the sea. Now if the weight of the mass uplifted be an element in determining the height to which the continents are raised, then we must allow this ice mass a decided influence in depressing the continental areas.

The reader may help himself to form a conception of the nature of these effects if he will float a rigid substance, such as a bar of wood, upon some semifluid, such as tar or treacle, weighting one end so that by its depression it may sink beneath the surface, thus elevating the other end. Now if he will add weight to the elevated end, subtracting it, if he please, from the other end, he will see the change in altitude which I conceive to have occurred by the accumulation of glacial matter. Another illustration, more satisfactory on the whole, is afforded by a little study of any of our frozen lakes. Let a weight be accumulated at any point on ice of moderate strength. The result is the depression of the ice at that point, and its elevation around the sunken point. In this condition the ridge and depression may well represent the state of the tensions which give its continent and sea basin. Now if we take a part of the weight from the depression and place it on the elevated part of the ice, we will thereby change the altitude of the elevation. If the hollow of the ice were filled with water this change would bring about an extension of the area covered with water, representing the invasion of the land by the sea during the glacial period. The fact that in a substance as rigid as ice these movements can take place without fracture, shows us that there is nothing in the solidity of the earth to prevent such movements.

It must not be thought that this view requires us to suppose the interior of the earth is a fluid mass, although it is quite reconcilable with that theory. I am inclined to cling to an opinion set forth by me some years ago that the central region of the earth is quite rigid, while between the outer fifty miles of strata and basement rocks, and the inner core of solid matter, there may remain a section which has not yet been completely solidified, and still admits of sufficient movement to give us the rise of the continental folds and the sinking of the sea floors. Nor am I satisfied that the condition of the mass on which the so-called crust rests, is such as can be called fluid, judged by the tests we apply to objects on the earth's surface. A rigidity such as belongs to the metals of average resistance to compression might permit such movements as we find to occur in masses urged by the enormous tensions to which our continents are subjected.

There can be hardly any question that the conclusion that the continents are kept in their attitude by constant tensions, is necessary and indisputable. As a factor in determining the position which any point occupies with reference to the centre of the earth, the weight of the mass supported must be of importance. Unfortunately the data for determining the value of this element are quite wanting; it seems evident enough, however, that we may more reasonably look to the weight of the ice accumulated on the continents during the glacial period for the depression of the land areas it occupied, than to any other cause. Only in this way can we account for the local character of the depression in many places, or for the coexistence of extensive subsidences in the southern as well as the northern hemisphere.

If this theory of the glacial depression be accepted we may obtain thereby a basis on which to compute the rigidity of the earth's crust as well as other important features connected with those parts of the earth, which though quite close to the surface, are beyond direct observation.[1]

[1] This report is meant to be preliminary to a more special and exhaustive study on the glacial and other dynamic phenomena of the coast of Maine.

XI. The Species of the Lepidopterous Genus Pamphila.

By Samuel H. Scudder.

Read March 25, 1874.

MANY European insects and their closely resembling American types are regarded by some entomologists as identical upon the two continents; by others, as distinct; and so far as butterflies are concerned, there is little to aid one in forming an opinion in any given case beyond the bare statements of naturalists, contending for opposing theories. In view of this condition of things, unimproved for the past thirty years, it is to be regretted that no one has given a systematic review of different cases, setting forth the reasonable grounds of opinion in each; this task properly belongs to the American student, since it is easier for him to procure an unlimited number of a given European species, than for a European naturalist to obtain the desired American types. Impressed with the importance of investigations in this direction, I have for some time been collecting material for such a study; and having recently had the pleasure of examining the extensive series of Hesperians brought by Mr. Theodore L. Mead from Colorado,[1] in which are many specimens of Pamphila, bearing close resemblance to *P. comma* of Europe, it has seemed a favorable opportunity of enquiring whether that species is represented on this continent, as held by some writers.[2] The result proves that although we have species which in many features closely resemble *P. comma*, there is not one which cannot be clearly distinguished from it. The richness of this genus in America, and its extreme poverty in the Old World (where only a single species is known), lead to the presumption that the genus had its origin in our own country, and that temperate North America is its proper metropolis. Nor is this theory incompatible with the opinion that *P. comma* is identical with any of the forms described below.

[1] For an opportunity of studying these, I am indebted to the courtesy of Mr. Mead and Mr. W. H. Edwards.

[2] For statements of this sort, see the following authorities:

Boisduval, Ann. Soc. Ent. Fr., 1852, 313; gives *P. comma* among the Californian butterflies, with the remark,—entirely similar to our European specimens.

Ib., Ann. Soc. Ent. Belg., xii, 23; repeats the same.

Koch, Geogr. Verbr. Eur. Schmett., 71; remarks that there are specimens in the Paris Museum from California.

Speyer, Geogr. Verbr. Schmett., i, 286; states that it is found on both sides of the Rocky Mountains, and specifies Canada and the northern United States (Lacordaire, Boisduval), Washington or Baltimore (Blanel in litt.), and California (Boisduval), as localities.

Walsh, Proc. Ent. Soc. Philad., iii. 215; gives the home of *P. comma* as California and Europe, on the authority of Boisduval.

So far as our knowledge of the seasons of apparition of these insects extends, it points to the same conclusion as the study of their colorational and structural features. Mr. Mead has taken specimens of four out of the five species more closely resembling *P. comma*[1]; and his notes upon them are so full that it is certain the species follow each other in the following order, at intervals of about a month: Nevada, Colorado, Manitoba, Juba. *P. Nevada* appears the second week in June, the male probably in the early part of the week, the female in the latter; the butterfly continues to emerge from the chrysalis during the month, and flies nearly to the end of July. *P. Colorado* probably appears during the second week in July and continues to emerge from the chrysalis until nearly the end of August, for Mr. Mead took fresh specimens during the second week of August, and of the female throughout the entire month; some individuals must therefore continue part way into September. *P. Manitoba* appears the first week in August, or perhaps even by the last of July, and continuing to emerge from the chrysalis throughout August, may doubtless be found until the middle of September. *P. Juba* probably appears by the middle of September, perhaps by the first of the month, and continues upon the wing at least through the first week in October, and probably until after the middle of the month. These statements are based on the condition of the specimens collected by Mr. Mead, all of which I have seen, every specimen labelled with the date of capture.

Nothing is known of the seasons of *P. Ottoe*, excepting that a rubbed male was taken in Iowa between the 21st and 24th of July. As to *P. Sassacus*, it is single brooded in the north, double brooded in the south, and probably hibernates as a chrysalis. In the south, the butterfly appears by the middle of April, and again, after ten days passed in the chrysalis, at the end of August. In New England, the earliest butterflies are seen during the last week in May, the female scarcely later than the male; sometimes they do not appear before the middle or latter part of the first week of June, and they evidently continue to emerge from the chrysalis until the middle of the month, and remain on the wing through June; battered individuals may sometimes be found until the middle of July. The female commences to lay eggs at least by the middle of June; the eggs hatch in twelve days.

Writing of the European species, *P. comma*, Meyer-Dür says:[2] "Since this butterfly is found from the lowest plains to the highest alpine meadows, at an elevation of seven thousand feet above the sea, its time of flight is very various; yet I believe that in the lowlands I have noticed two generations, since the earliest appear around Burgdorf about the 17th of June, and disappear about the middle of July; on August 21st fresh individuals again fly in similar spots, and they disappear about the beginning of September. On the heights of the Jura and the Alps, there is but one generation, which appears midway between these two, namely, in August. This mountain form, which I have collected between the 6th and 10th of August on the top of the Grimsel, on the Meyenwand, in the Valais above Varon, Leuk, and on the Gemmi, and, later, August 14th, on the Jura, is peculiar for the remarkable size of the female, its darker ground color and more sharply defined clear yellow spots, as compared with the butterflies of the plains. . . . Keitel calls

[1] The seasons of the fifth, *P. sylvanoides*, are unknown; but this species was separated from *P. comma* by Boisduval himself in his first paper on Californian Lepidoptera.

[2] Schmetterlinge der Schweiz, 216–7.

his Lapland specimens by a distinct name — *Cattena* [*sic*]. I can, however, find no difference between them and our alpine forms, excepting that the ground color of the underside of the hind wings, and of most of the fore wings, is even darker olive green than in butterflies from the summit of the Grimsel; in the butterflies of the lowlands, these parts are beautiful yellow green."

It will be seen from the above that the two best known species of Pamphila, *P. comma* and *P. Sassacus*, are double-brooded, at least in the low countries. It seems therefore, at first sight, possible that the differences we have noted between Nevada and Manitoba, and between Colorado and Juba, may be similar to those sometimes observed in double brooded insects; that is, that these may in each case be seasonal forms of a single species. But when we recollect, 1st, that no such distinctions have been noticed between the two broods of *P. comma* or of *P. Sassacus* (though these have not been sufficiently studied to give this consideration great weight); 2d, that these Coloradan species have thus far been found only at considerable elevations (see below, in our remarks on their geographical distribution), in regions corresponding to those in which *P. Sassacus* and *P. comma* are single brooded; and 3d, that no differences can be found in the abdominal appendages of the typical comma and the subarctic Catena, at all comparable to those which distinguish *P. Colorado* and *P. Juba*, or (and especially) *P. Nevada* and *P. Manitoba*; we are forced to the conclusion that this interpretation of their differences cannot be maintained. Wishing, however, to get all possible light upon this subject, I wrote to Mr. Mead, as the only one familiar with these insects, their haunts and seasons, suggesting the possibility of such a hypothesis. He replied: "I do not think any of the Colorado Pamphilas are likely to be specimens of a second brood. All the Hesperians whose larvæ I have experimented on take a long time to complete their transformations,[1] and the season in Colorado is so very short that I do not recollect any species [of butterfly] of which there is a second brood in the mountains where these Pamphilas were taken. Besides, the late ones were considerably less common than the early species, which would not probably be the case with a second brood."

This genus of butterflies belongs to the north temperate zone. The single species of the Old World is found from the Atlantic to the Pacific, between the 35th and 60th degree of latitude; the northernmost points from which it has been recorded are northern Scandinavia and Finland; and the southernmost, Corsica, Syria, and the Altai Mountains in Asia. In America, the group, although much more abundant in species, extends only from the 32d to the 53d degree of latitude, but as in the Old World, occurs from ocean to ocean. *P. Sassacus* extends further south than any of the other species, having been found common in Georgia (Abbot). *P. Manitoba*, on the other hand, is the most northern, and, at the same time the most widespread, occurring as far north and in as widely separated localities as Rivière du Loup on the St. Lawrence, northern Lake Winnipeg in the interior, and Labache on the Pacific slope. It occurs also in Colorado, where it is accompanied by *P. Nevada* and *P. Colorado*. *P. Nevada* extends west from Colorado to the Pacific, and is found as far north as Oregon; but *P. Colorado* is confined to the district whose name

[1] This is almost universally true, yet not a few of the New England species are double-brooded, even, I believe, including the northern *Cyclopides Mandan*; and one, *Ancyloxypha Numitor*, is pretty certainly triple-brooded.

it bears,[1] as *P. sylvanoides* is to California. The region in Colorado, explored by Mr. Mead, is generally over seventy-five hundred feet above the sea; potatoes, he informs me, will grow at eight thousand, or perhaps eighty-five hundred feet, and at nine thousand feet no vegetables can be raised. The lower table lands have an elevation of six thousand feet, so that the species inhabiting this region are all insects of high altitude. *P. Juba*, again, extends from the Great Salt Lake to California; within the limits of the United States, east of the Rocky Mountains, only two species occur: *P. Ottoe*, west of the Mississippi, in the Indian Territory, Kansas and Iowa; and *P. Sassacus*, which spreads from the Great Plains to the Atlantic, and along the seaboard from Maine to Georgia.

For readier determination of these species I have added separate tables, drawn from the markings of the wings and from the abdominal appendages.

TABLE TO DETERMINE THE MALES OF THE SPECIES OF PAMPHILA; DRAWN FROM THE ORNAMENTATION OF THE WINGS.

1. Upper surface of hind wing almost wholly tawny, with a very narrow dusky or dark brown border 2.
1. Upper surface of hind wings largely obscured with dusky, or with a very broad dusky or dark brown border . . . . . 3.
   2. More than 36 mm. in expanse; under surface of hind wings with scarcely any markings . **Ottoe.**
   2. Less than 36 mm. in expanse; under surface of hind wings distinctly marked with an irregular mesial band of partially connected spots . . . . . **Nevada.**
3. Discal dash of upper surface of fore wings followed, in the lower median and medio-submedian interspaces, by a narrow belt of blackish scales . . . . . **sylvanoides.**
3. Discal dash of upper surface of fore wings not followed by any row of dusky scales along its lower edge . . . . . 4.
   4. Under surface of hind wings with an irregular mesial band composed of distinct large, squarish, nearly uniform spots . . . . . **Juba.**
   4. Under surface of hind wings with a scarcely perceptible, irregular mesial band of nearly uniform spots . . . . . **Sassacus.**
   4. Under surface of hind wings with an irregular mesial band, composed of distinct, small or rather small spots, seldom uniform . . . . . 5.
5. Band crossing under surface of hind wings bent at an angle of about 50°, the band much constricted near the angle . . . . . **Colorado.**
5. Band crossing under surface of hind wings bent at an angle of about 60°–75°, the spots near the angle only a little, if any, smaller than the others . . . . . 6.
   6. Each of the spots forming the mesial band of the under surface of the hind wings distinct, often narrowly edged on the outer and inner edges with black, the ground of the wing almost always rather heavily flecked with dark green . . . . . **comma.**
   6. The spots of the mesial band of the under surface of the hind wings confluent, or nearly so, almost never and then but slightly edged with black, the ground of the wing but slightly flecked with not very dark green . . . . . **Manitoba.**

TABLE TO DETERMINE THE FEMALES OF THE SPECIES OF PAMPHILA; DRAWN FROM THE ORNAMENTATION OF THE WINGS.

1. The paler markings of the under surface of the wings white or silvery white, conspicuous . . . . 3.
1. The paler markings of the under surface of the wings either inconspicuous, a little paler than the ground color of the wings, or altogether wanting . . . . . 2.
   2. A large species, expanding more than 36 mm., destitute of markings beneath[2] . . . . . **Ottoe.**
   2. A small species, expanding less than 36 mm., with inconspicuous markings beneath . **Sassacus.**

[1] Since writing this, it has been taken in Arizona.

[2] It is here assumed that the female of *P. Ottoe*, which is unknown, will resemble the male. There can scarcely be a doubt that any markings it may have beneath will be as inconspicuous as in *P. Sassacus*, and that it can be instantly distinguished from that by its much greater size.

3. Fore wings with semi-hyaline spots in the median interspaces . . . . . **sylvanoides.**
3. Wings without trace of hyaline spots . . . . . 4.
4. Ground color of under surface of hind wings grayish green . . . . . 5.
4. Ground color of under surface of hind wings, olive or yellow green . . . . . 6.
5. A large species; markings on under surface of fore wings, below the middle median nervure, generally very ill-defined; hind wings slightly but distinctly produced next the inner portion of the outer margin; band of under surface of hind wings broad and usually connected; inner area of same surface tinged distinctly with buff; distinct blackish patches at the base of the median interspaces on the upper surface of the fore wings . . . . . **Juba.**
5. A rather small species; markings on under surface of fore wings, below the middle median nervure, generally well-defined, at least above; hind wings with a scarcely perceptible fullness to the outer margin next the inner border; band of under surface of same wings moderately broad, often broken; inner area of same surface slightly paler than the rest, but scarcely tinged with buff; faint dusky patches at the base of the median interspaces on the upper surface of fore wings; or, usually, these parts are no darker than the surrounding field . . . . . **Nevada.**
6. Mesial band of the under surface of the hind wings bent at an angle of about 45° or 50°; spots of this band generally vivid, approaching the outer margin of the wing so closely in the interspace beyond the cell as to be removed from it by less than their own width . . . . **Colorado.**
6. Mesial band of the under surface of the hind wings bent at a right angle, or a little less than a right angle, the spots generally not very vivid, separated from the outer margin in the interspace beyond the cell by at least their own width, and ordinarily by much more than that . . . . . 7.
7. Spots in the interspace beyond the cell generally smaller than the others which make up the mesial band of the under surface of the hind wings, giving the band an irregular appearance; spots of the lower portion of the band generally confluent; the V-shaped spot, traversing the cell near its extremity, very seldom crossing the median nervure to the medio-submedian interspace and not enlarged there; basal half of fringe on the hind wings, as seen beneath, generally not at all or very inconspicuously interrupted with dusky at the nervure tips . . . . . **Manitoba.**
7. Spots of the mesial band on the under surface of the hind wings pretty uniform in size, those of the interspaces beyond the cell seldom any smaller than the others, so that the band has a more regular appearance than in *P. Manitoba*; spots of the lower portion of the band distinctly marked, sometimes even independent; the V-shaped spot traversing the cell near its extremity, always crossing the median nervure to the medio-submedian interspace and enlarged there; basal half of fringe on the hind wings, as seen beneath, generally conspicuously interrupted with blackish at the nervure tips . . **comma.**

TABLE TO DETERMINE THE MALES OF THE SPECIES OF PAMPHILA; DRAWN FROM THE ABDOMINAL APPENDAGES.

1. Hook and lateral arms of upper organ separated by a deep cleft, about half the length of the horizontal portion of the organ; hook slender, as viewed from above; clasps not extending nearly so far back as the upper organ . . . . . 2.
1. Hook and lateral arms of upper organ separated by a slight cleft not quarter the length of the horizontal portion of the organ; hook very stout as viewed from above; clasps extending almost or quite as far back as the upper organ . . . . . 3.
2. Hook and lateral arms nearly parallel, and but slightly separated . . . . . **Nevada.**
2. Hook and lateral arms opposed to each other by opposite curves, leaving a fusiform space between them, as viewed laterally . . . . . **Sassacus.**
3. Clasps, when viewed exteriorly, with two conspicuous superior apical teeth . . . . . 4.
3. Clasps with but one conspicuous apical tooth . . . . . **sylvanoides.**
4. Apical teeth of clasp equally separated from each other from base to summit; clasp itself much broader at base than elsewhere, about twice as long as broad . . . . . 5.
4. Apical teeth of clasp diverging slightly from each other; clasp itself elongated, tapering but little, much more than twice as long as broad . . . . . **Ottoe.**

5. Apical teeth of clasp very closely approximated, often appearing at first sight as if single; anterior inner edge of apical tooth but little produced as a slightly and bluntly toothed lamina; a distinct notch in advance of the preapical tooth; posterior border of clasp subangulated, scarcely produced beyond the apical tooth . . . . . 6.

5. Apical teeth of clasp less closely approximated, readily distinguishable; anterior inner edge of apical tooth produced as a sharply and distinctly denticulate lamina; no distinct notch in advance of the preapical tooth; posterior border of clasp rounded, produced considerably beyond the apical tooth . 7.

6. Apical teeth of clasp very closely crowded together, the preapical slightly the longer; lamina continuing the inner anterior edge of the apical tooth moderately high . . . . . **Colorado.**

6. Apical teeth of clasp not so closely crowded together, and of equal length; lamina continuing the inner anterior edge of the apical tooth very low and inconspicuous . . . . . **Manitoba.**

7. Posterior margin of clasp smooth, rounded; inner anterior edge of apical tooth forming a denticulate lamina, more nearly transverse than horizontal in its relation to the clasp, the largest denticulations above, the lamina terminating gradually, opposite the posterior border of the preapical tooth . **Juba.**

7. Posterior margin of clasp ragged and irregular; inner anterior edge of apical tooth forming a denticulate lamina, more nearly horizontal than transverse in its relation to the clasp, the denticulations as large below as above, the lamina falling abruptly off at its anterior extremity opposite the anterior border of the preapical tooth . . . . . **comma.**

DESCRIPTIONS OF THE SPECIES OF PAMPHILA.

1. Pamphila Sassacus.

Pl. x, ♂ Fig. 5, ♀ Fig. 6. Pl. xi, Figs. 9, 12, 14.

Pamphila Sassacus Kirb., Syn. Cat. Diurn. Lep., 599; Scudd.! Syst. Rev. Am. Butt., 56.
Hesperia Sassacus Harr.! Ins. inj. Veg., 3d ed., 315.

This familiar species is readily distinguished from the others; the wings are broadly and distinctly bordered above with dark brown, which does not gradually merge into the orange-tawny base; and both sexes have a distinct longitudinal dash of dark brown in the basal half of the interspaces beyond the cell, barely separated from the dark border of the wing, and much more distinct than in the other species; it is present in the others to a greater or less extent, but is generally wholly absent from the extreme base of these interspaces, and is never conspicuously contrasted with the neighboring parts; while here it resembles Napa Edw.,[1] to which species this bears a strong resemblance upon both its upper and under surface. The under surface of the hind wing differs from most of the species in the faintness of the mesial band; it is not, however, so faint as in *P. Ottoe*, and it is larger than these, consisting, when most conspicuous, of a faint series of pale, quadrate, equal spots of moderate size in the subcostal and median interspaces, longer than broad, forming a regular curve, their outer edges removed by the length of the spots from the outer border, and those of the two areas connected by a similar spot in the subcosto-median interspace, removed from the border by only half, or less than half, the distance to which the others are distant from it. Upper organ strongly arched, very deeply sulcate above posteriorly; hook two-thirds the length of the centrum (or the mass of the horizontal portion of the organ), nearly straight, equal and very slender, as viewed above, tapering delicately

[1] *Hesperia Napa* Edw., does not belong to this genus, as asserted in my Systematic Revision, but is congeneric with *Hesperia Mystic* Edw., which again must be separated from Limochores. The two species form a group hitherto uncharacterized, and to which I apply the name Pyrrhosidia with *Hesperia Mystic* Edw. as the type.

as seen from the side, the apical half compressed, laminate; lateral arms similarly compressed, but tapering only at the tip, longer than the hook, widely separated from it at their base, curving upward. Clasps nearly twice as long as broad, not extending nearly so far backward as the upper organ, the upper edge broadly angled near the base, its apical half a little incurved, the sharply pointed apical denticle a little incurved, and separated widely by a deep rounded excision from a much larger, but equally pointed, upturned and slightly recurved tooth at the extremity of the upper margin of the clasp; the recurved edge of the lower margin forms a uniformly serrated lamina supporting the inner anterior edge of the apical tooth, and terminates anteriorly in a pointed upturned tooth opposite, and similar to, the preapical tooth of the upper edge of the clasp.

Excepting *P. Manitoba*, which has once been found on the lower St. Lawrence, it is the only eastern species in America, but it extends as far west as Iowa (Allen) and Nebraska (Dodge), and is common, according to Abbot, in Georgia. It is abundant in the southern half of New England, and has been taken as far north as Norway, Me., (Smith). I do not know of its occurrence in Canada.

2. **Pamphila Nevada** nov. sp.

Pl. x, ♂ Figs. 1, 4, ♀ Figs. 2, 3. Pl. xi, Figs. 3, 4, 4*a*.

Judging from the specimens which have fallen into my hands, this is the most abundant species in the west, and it is one of the most widely spread, having been taken in Colorado, California, Nevada and Oregon. Specimens from the latter region are a little paler upon the under surface than those from more southern localities, and the same is true of the upper surface of the females. The species is of the size of *P. comma*, and the males differ from those of *P. comma*, and of all the other species of the genus (excepting the larger *P. Ottoe*), in the clearness of the upper surface of the wings; occasionally the wings are somewhat suffused with dusky, but usually the hind wings have but a narrow edging of blackish, broadened, naturally, along the costal border; and the fore wings, instead of having a distinctly limited bordering, as is common to a greater or less extent in most species, have the wing gradually more and more suffused with a warm but dusky tint toward the tip, as is not unfrequently the case in *P. comma*; sometimes the mesial belt of the under surface is visible above, but occasionally, at least, it is wholly absent. The female scarcely differs, upon the upper surface, from the females of *P. Manitoba* and *P. comma*, except in almost uniformly having the small subapical spots, both those near the costal, and those near the outer border, paler than the others, or nearly white, as occasionally happens in the female of *P. comma*. Beneath, the mesial white band of the hind wings is more irregular and scattered than in *P. comma* or *P. Manitoba*; in the male it is usually broken up into four separate patches, connected, by their angles only, into a continuous angular belt; three of these patches, of nearly equal size, but the middle one usually the largest, lie in a straight line parallel to the longer axis of the wing, situated one each in the subcostal and subcosto-median interspaces; the last patch, not much larger than the second, is composed of three confluent spots in the median and medio-submedian interspaces, as far from the outer border as the second patch, the medio-submedian spot farther removed from the border than the rest; the ground color of the wing is a greenish griseous, and the spots are narrowly edged exteriorly and interiorly with blackish. The markings of the female are similar, excepting

that they are usually a little larger and more obviously continuous, often sending out on the exterior border little shoots of white along the nervures. Winnipeg specimens of *P. Manitoba* seem to approach this species closely in the markings of the wings. Upper organ bent at a right angle in the middle and scarcely rounded, deeply sulcated posteriorly above, along the middle; hook almost three-fourths the length of the centrum, straight, moderately stout at the base, as seen from above, where it tapers rapidly, afterwards slender and gently tapering; lateral arms slender, gently tapering, nearly straight, but little separated at the base from the hook, upturned at the tip to meet the hook, which they slightly exceed in length. Clasps rather small, twice as long as broad, not extending nearly so far back as the upper organ, narrowing pretty regularly from the base, the upper margin incurved and slightly deflexed, the posterior border rounded and protuberant; the preapical tooth is longer than the apical, very slender and curved, like the apical, a little forward; they are separated from each other by a deep, rather wide, rounded excision; the apical tooth is supported by a serratulate lamina, which is the continuation of its inner anterior edge, and which terminates by a conspicuous serratulate denticle opposite the posterior edge of the preapical tooth.

It has been taken in Colorado by Mr. Mead, on the mountains about the South Park and in the Park itself. Mr. W. H. Edwards has also sent me specimens from Nevada, California and Oregon, the last collected by Dr. Gabb.

3. Pamphila Ottoe.

Pl. x, ♂ Fig. 6. Pl. xi, Figs. 13, 16.

Pamphila Ottoe Kirb., Syn. Cat. Diurn. Lep., 602; Scudd.! Syst. Rev. Am. Butt., 57.
Hesperia Ottoe Edw.! Proc. Ent. Soc. Philad., vi, 207.

This species differs considerably from all the others, not only in its greater size and paler color, but in the almost total absence of any markings upon the under surface of the hind wings; faint spots are occasionally visible upon the otherwise uniform yellowish tawny surface. It approaches *P. Nevada* upon the upper surface in the narrowness of the bordering band of dark brown, which even on the front wing does not extend far from the margin. I have not seen the female, nor has it yet been described. Upper organ very stout, strongly arched, rather deeply sulcate above posteriorly; centrum very broad above, scarcely narrowing posteriorly until the hook is reached, which is scarcely one-fifth the length of the centrum, when it tapers rapidly to a very bluntly rounded apex; lateral arms closely resembling those of *P. Manitoba*. Clasps very large, extending quite as far backward as the upper organ, nearly two and a half times longer than broad, not narrowing greatly, the upper margin a little elevated near the base, the posterior margin rounded and a little protuberant, the apical tooth a little incurved next the base, beyond upright, considerably shorter than the nearly erect, incurved, stout, preapical tooth, from which it is separated by a pretty deep and rather wide, rounded excision, widening above; it is supported within by a low, slightly denticulate, or sinuate lamina, the extension of its inner anterior edge, which terminates in a slight denticle at some distance anterior to the preapical tooth.

The species has been found in Kansas, Iowa, and according to Mr. Edwards, in the Indian Territory.

4. Pamphila Colorado nov. sp.

Pl. x, ♂ Fig. 18, ♀ Figs. 16, 17. Pl. xi, Figs. 1, 2.

Upon its upper surface this species differs from *P. Manitoba*, with which it agrees in size, in scarcely any other particulars than the rather darker bordering in the males, and the more conspicuous transverse mesial band of the hind wings in the females. Beneath, the ground color varies from olivaceous to griseous green, and the mesial belt of the hind wings is peculiar for the manner in which it diminishes in width where it bends at the middle; it is apparently made up of three patches: a lozenge-shaped patch in the lower subcostal interspace; a rather broad belt, nearly uniform in width, but irregular in outline, crossing the median and part of the medio-submedian interspaces; and a similar belt, but only half as wide, crossing the interspace beyond the cell, its outer limit on a line with the outer limit of the previously mentioned belt, and its upper interior angle reaching toward the tip of the lozenge-shaped patch; these spots are generally bordered narrowly with blackish. In the female the spots are generally larger, more frequently parted, less regularly disposed, and occasionally accompanied by a spot in the upper subcostal interspace. Upper organ rather small, strongly arched, sulcate above posteriorly, the centrum, hook and lateral arms almost exactly as in *P. Manitoba*. Clasps not large, yet extending as far as the upper organ, fully twice as long as broad, tapering pretty regularly, the posterior margin roundly angulated, the two teeth scarcely separated by a very deep, equal, rounded excision, the preapical slightly the larger and more incurved, the apical followed within anteriorly by a rather stout but low lamina, furnished with one or two small tubercular dentations opposite the preapical tooth.

This species has been taken in Colorado, about the Georgetown and South Park Roads by Mr. Mead; and in Arizona, by Lieut. Wheeler's expedition.

5. Pamphila Juba.

Pl. x, ♂ Fig. 19, ♀ Fig. 20. Pl. xi. Figs. 5, 6.

Pamphila Juba Scudd.! Syst. Rev. Am. Butt., 56.
Hesperia comma Boisd.! Ann. Soc. Ent. Fr., [2] x, 313 (nec Linne).

This species of Pamphila is larger than any others, with the exception of *P. Ottoe*, which scarcely exceeds it, but on the upper surface resembles closely the preceding, differing from it in having the mesial band of the under side of the hind wings more conspicuous upon the upper surface of the males than in *P. Coloradu*. The females are peculiar for their pale appearance, due to three causes: a really paler tint to the tawny parts of the wing, in which respect they resemble the Oregon specimens of *P. Nevada*; a narrow dark outer border to the wings; and the much broader mesial belt of the hind wings; more than in any other species the interior edge of the outer margin of the fore wings of the female is very crenate, the brighter ground following the nervules nearly to the margin of the wing, while at the base of the lower median interspace and in the interspace below it are a couple of continuous or nearly continuous dark brown patches resembling those which so often accompany the inferior edge of the discal patch of the males in this group of Urbicolæ. Beneath they are peculiar in having the mesial band of the hind wing broader than in any other species, and rather more uniform than usual, the spots of which it is composed

being white, nearly square and equal, and forming a belt, bent in the middle almost exactly at a right angle, or in the females at slightly less than a right angle; in the males the belt is almost wholly continuous, although sometimes broken at the lower subcostal nervure, but in the females it is usually broken both here and at the upper median nervule; the ground color in both sexes is a greenish griseous. Upper organ as in *P. Colorado*, but considerably stouter. Clasps not large, extending nearly as far as the upper organ, nearly or quite as long as broad, the upper border furnished with a slight swelling next the base, but otherwise tapering regularly; the posterior margin well rounded, extending considerably beyond the apical tooth, as in *P. comma*; this is slightly shorter than the preapical tooth, and separated very narrowly from it by a deep rounded excision; both the teeth are incurved, but nearly erect; the inner anterior edge of the apical tooth is sharply denticulated, but it hardly extends forward into a serrated lamina.

This butterfly occurs in California and in the neighborhood of Salt Lake City, Utah.

6. Pamphila comma.

Pl. x, ♂ Figs. 12, 13, ♀ Figs. 14, 15. Pl. xi, Figs. 10, 11.

Pamphila comma Fabr., Ill. Mag. Ins., vi, 287.
Hesperia comma Linn., Syst. Nat., Ed. x, 484.

This species is too well known to require a description of the ornamentation of the wings (see, however, the description of the succeeding species); but the abdominal appendages are now described for the first time.

Upper organ strongly arched, rather deeply sulcate above, posteriorly; hook one-third the length of the centrum and slightly curved downward; together with the centrum it is very broad at the base above, tapers roundly to a rounded apex, and is but little longer than broad; viewed from the side the hook is nearly equal, the apex pointed beneath; lateral arms equal, cylindrical, tapering a little at the tip, not very widely separated from the centrum at their base, curving slightly upward, of equal length with the hook. Clasps about twice as long as broad, extending fully as far back as the upper organ, narrowing pretty regularly from the base, the upper margin incurved and deflexed, the posterior border rounded, extending beyond the apical tooth, and of a somewhat ragged outline; the preapical tooth is somewhat longer than the apical, but is incurved to such a degree as to appear of the same length on a lateral view; otherwise they are both nearly straight, upturned and narrowly separated by a very deep rounded excision; the irregularly serrated lamina supporting the inner anterior edge of the apical tooth possesses five or six slight serrations, and the lamina terminates abruptly opposite the anterior edge of the preapical tooth.

The appendages of the northern form (Catena) seem to differ from those of the normal type only in sometimes having the preapical tooth no longer, or but very slightly longer than the apical; and in that the two teeth are always separated by a slightly wider interval than in the normal form, approaching in this respect *P. Nevada*, and departing more widely from *P. Manitoba*.

This insect occurs in the north temperate zone of the Old World; some details of its distribution are given in the introduction.

7. Pamphila Manitoba nov. sp.

Pl. x, ♂ Figs. 8, 11, ♀ Figs. 9, 10. Pl. xi, Figs. 7, 8.

This species is the most nearly allied to *P. comma* of all American species; the size of the two is the same, and the upper surface of the females vary in each species to the same extent; there are no constant features of distinction in the upper surface of the male, although in *P. Manitoba* the hind wings are usually devoid of the appearance of the spots on the under surface, which generally are faintly but exactly marked upon the upper surface in the European species. The under surfaces of the two species also resemble each other closely, and it is a little difficult to define in words the distinctions which are apparent: the ground color inclines more to deep green in *P. comma*, and the mesial bent band of the hind wings is rather more uniform; in the male it seldom departs from a certain regularity of disposition, the spots being nearly equal, arranged in a line bent at a little less than a right angle, occasionally broken into spots, and sometimes with a narrow black bordering to the spots upon the inner and outer side. In the male of *P. Manitoba*, the spots generally diminish in size toward the middle of the wing, and from the greater approximation to the outer border (shown by the spot in the interspace beyond the cell), the band is bent at considerably less than a right angle; the spots are never bordered with black, at least in specimens I have seen. The female of *P. comma* agrees very well with the male of the same in its characteristics, only the band is somewhat broader, and perhaps more frequently made up of detached spots, while the female of *P. Manitoba* differs to a greater degree from its male, the spots showing greater tendency to become equal in size, to separate from each other, and even to become margined slightly with black; it is therefore less readily distinguished from the same sex of *P. comma* than the males are; there is also great variation in the breadth of the band or the size of the spots, for while usually larger than in the male (as in most species) they are sometimes many times larger, and occasionally almost as small as in the most delicately marked males. Upper organ bent at a right angle in the middle, and rounded; sulcated above, as in *P. comma*; the hook and lateral arms closely resemble those of *P. comma*, but are slightly shorter, the hook only about one-fourth the length of the centrum. Clasps a very little more than twice as long as broad, closely resembling those of *P. comma*; the posterior border is, however, smoothly rounded, and not so protuberant; the teeth are of equal length, similarly incurved, and very narrowly separated by a very deep rounded excision; the lamina supporting the inner anterior edge of the tooth is very slight, having but one or two dentations and then disappearing.

It is a wide-spread species, having been taken in Colorado by Mr. Mead, about Pike's Peak (Edwards), on the shores of Lake Winnipeg, by the late Mr. Kennicott and myself, by the late Mr. Crotch at Labache, and at Rivière du Loup by Mr. Couper.

8. Pamphila sylvanoides.

Pl. x, ♂ Fig. 20, ♀ Fig. 21. Pl. xi, Figs. 15, 17.

Pamphila sylvanoides Kirb., Syn. Cat. Diurn. Lep., 602.
Hesperia sylvanoides Boisd.! Ann. Soc. Ent. Fr., [2] x. 313.
Augiades sylvanoides Edw., Syn. N. Am. Butt., 45.
Pamphila Columbia Scudd.! Syst. Rev. Am. Butt., 56.

This butterfly, which is most nearly allied to the preceding, and is rather smaller than *P. comma*, differs from all the species of this genus in that the discal dash upon the upper surface of the fore wings in the male appears nearly twice as broad as usual, from the presence of a patch of dark brown scales along its inferior surface; the upper surface of the fore wing of the female also differs from that of any other species in having a quadrate transparent spot in the lower median interspace just below the last divarication of that nervure, and a partially transparent triangular patch at the extreme base of the upper median interspace; these are not given with sufficient distinctness in the plate; besides the three little yellowish subapical patches lying one beneath the other next the costal margin, as mentioned by Boisduval, there are two similar but squarer patches in the interspaces beyond the cell and nearer the outer margin. The upper surface of the hind wing of the male does not differ from its usual appearance in *P. Manitoba*; that of the female is mostly dusky, with a tawny patch near the base, and in the middle of the outer half of the wing a broad, tawny, transverse patch, double the breadth of the belt of the under surface. Beneath, a silvery white (♂) or pale (♀) slender belt of small quadrate spots, similar to that of *P. comma*, bent at a little less than a right angle, the portion at right angle to the inner border straight and continuous, the other portion sometimes broken, sometimes continuous and straight. Upper organ strongly arched, deeply sulcate above posteriorly; hook about one-third the length of the centrum (but in the only male specimen at hand, broken; doubtless of the Comma type); lateral arms cylindrical, very slightly tapering, not very widely separated at their base, beyond straight. Clasps about twice as long as broad, not extending so far backward as the upper organ, narrowing pretty regularly; the posterior border well rounded, scarcely extending beyond the apical tooth, which is pretty large, erect, triangular, pointed and separated, not widely, by a moderately deep, rounded excision, from the preapical tooth; this is but a slight, triangular, compressed denticle, removed from the upper edge of the clasp, the height of which it attains, by a slight excision; the lamina supporting the inner anterior edge of the apical tooth is distinctly and sharply serrated, terminating some distance in advance of the preapical tooth by a serration twice as large as the others, and much larger than the preapical tooth itself.

The species has only been taken, and rarely, in California.

Explanation of Plates.

PLATE X.

The illustrations are chromolithographs drawn directly from specimens; nine stones having been used by Messrs. Sinclair and Son of Philadelphia, to whom my thanks are due for the care they have taken in the production of the plate.

Fig. 1. *P. Nevada*, ♂, from Colorado. Collected June 12, by T. L. Mead.
Fig. 2. *P.* " ♀, from Oregon. Received from W. H. Edwards.
Fig. 3. *P.* " ♀, from Colorado. Collected June 17, by T. L. Mead.
Fig. 4. *P.* " ♂, " " " June 23, " "
Fig. 5. *P. Sassacus*, ♂, from New England. Collected by S. H. Scudder.
Fig. 6. *P. Ottoe*, ♂, from Kansas. Received from W. H. Edwards.
Fig. 7. *P. Sassacus*, ♀, from New England. Collected by S. H. Scudder.

Fig. 8. *P. Manitoba*, ♂, from British Columbia. Collected by G. R. Crotch.
Fig. 9. *P.* " ♀, from Pike's Peak. Received from W. H. Edwards.
Fig. 10. *P.* " ♀, from East Coast Lake Winnipeg. Collected Aug. 2, by S. H. Scudder.
Fig. 11. *P.* " ♂, from Labache. Collected by G. R. Crotch.
Fig. 12. *P. comma*, ♂, var. *Catena*, from Northern Norway. Received from O. Staudinger.
Fig. 13. *P.* " ♂, from Germany. Received from O. Staudinger.
Fig. 14. *P.* " ♀, from Rennes, France. Received from P. Mabille.
Fig. 15. *P.* " ♀, var. *Catena*, from northern Norway. Received from O. Staudinger.
Fig. 16. *P. Colorado*, ♀, from Colorado. Collected by T. L. Mead.
Fig. 17. *P.* " ♀, " " " Aug. 28, by T. L. Mead.
Fig. 18. *P.* " ♂, " " " July 13, " "
Fig. 19. *P. Juba*, ♂, from Utah. " Oct. 2 " "
Fig. 20. *P.* " ♀, " " " " " "
Fig. 21. *P. sylvanoides*, ♀, from California. Received from W. H. Edwards.
Fig. 22. *P.* " ♂, " " " Henry Edwards (No. 122). This is also the type of *P. Columbia* Scudd. See also Pl. XI, fig. 17.

PLATE XI.

For the originals of this plate, illustrating the abdominal appendages of the males, I am indebted to the kindness of Mr. Edward Burgess, the Secretary of the Society, who has spent a great deal of time in their dissection and delineation. They are magnified eighteen diameters.

Fig. 1. *P. Colorado*, Distal half of left clasp; interior view.
Fig. 2. *P.* " Distal half of right clasp; exterior view.
Fig. 3. *P. Nevada*. The appendages viewed from the right side.
Fig. 4. *P.* " Extremity of left clasp; interior view. 4*a*, terminal anterior prominence of the lamina supporting the apical tooth, enlarged a little more.
Fig. 5. *P. Juba*. Distal half of left clasp; interior view.
Fig. 6. *P.* " Distal half of right clasp; exterior view.
Fig. 7. *P. Manitoba*. The appendages, viewed from the right side.
Fig. 8. *P.* " Distal half of left clasp; interior view.
Fig. 9. *P. Sassacus*. The appendages, viewed from the right side.
Fig. 10. *P. comma*. The appendages, viewed from the right side.
Fig. 11. *P.* " Distal half of left clasp; interior view.
Fig. 12. *P. Sassacus*. Distal portion of left clasp; interior view.
Fig. 13. *P. Ottoe*. Distal half of left clasp; interior view.
Fig. 14. *P. Sassacus*. Distal portion of right clasp; interior view.
Fig. 15. *P. sylvanoides*. Distal half of right clasp; interior view.
Fig. 16. *P. Ottoe*. Right clasp; exterior view.
Fig. 17. *P. sylvanoides*. Distal half of left clasp; interior view.

The specimens which form the basis of this plate were taken at the following localities: —

P. Colorado — Colorado; collected July 13, by T. L. Mead.
P. Nevada — Colorado; collected June 17, by T. L. Mead.
P. Juba — Utah; collected Oct. 2, by T. L. Mead.
P. Manitoba — Labache; collected by G. R. Crotch.
P. Sassacus — New England; collected by S. H. Scudder.
P. comma — (the normal type) Switzerland; purchased.
P. Ottoe — Iowa; collected last of July, by J. A. Allen.
P. sylvanoides — California; same specimen as Pl. x, Fig. 22.

SCUDDER ON THE SPECIES OF PAMPHILA

SCUDDER ON THE SPECIES OF PAMPHILA

XII. On the Antiquity of the Caverns and Cavern Life of the Ohio Valley.[1]

By N. S. Shaler.

Read December 2, 1874.

Introduction.

Cavern animals, always interesting, have acquired an importance quite unexpected by their first students since the questions concerning the origin of organic species assumed their present shape. Whenever we find any animal, especially a highly organized form, living in the perpetual darkness and uniform temperature of a cavern, we are entitled to look for something which marks its departure from the usual conditions of life. If organic forms are the direct product of their environment, then the change from the sunlit upper world to the cavern conditions must lead to modifications of the most important character. These changes have, in fact, been found, and as a general rule they most affect those parts of the body which are the most directly concerned with the phenomena of the outer world. Organs of sight, or organs which may replace sight, are the most affected. We see here organs like the vertebrate eye, which traces its development down all the infinite ages to the silurian or more ancient seas, fading like a shadow in this darkness. Among insects, where the visual organs are essentially as complicated, and date their origin from a time almost as remote as the vertebrates, we have the same marvelous change, though the known and interminable variation amongst this class of animals makes the phenomena less striking. These changes must be studied in their detail before we shall know their full value. There is one other point, however, to which attention must be called before we come to the main object of our study, viz., how far is this hidden life connected with the life of the outer world in the same neighborhood. Collections formed for the special purpose of determining this point have already been made by the officers of the Kentucky Geological Survey, and in time it is hoped they may afford the means for specially discussing the matter of the affinities of the several species found in the caverns to the outside forms. At present it suffices to anticipate the special study by the statement, already warranted by the investigation of these forms of life in other regions, that there is in most cases a close connection between the life within our caves and that in the neighboring country.[2] If

[1] This paper is published in accordance with the provision of the law constituting the State Surveys of Kentucky, which authorizes the director to publish in any scientific journal, in advance of the regular reports, any part of the scientific results of the Surveys.

[2] I am greatly indebted to my friends and fellow workers, Messrs. Packard, Putnam and Sanborn, for facts which have led to this conclusion, and must refer the reader to their forthcoming reports for a complete view of the relations of these cavern species.

organic life be entirely the product of certain internal generating forces, still more, if it be the result of anything like special creative acts, then it is impossible to find any good reason for this correspondence; if, on the other hand, it is largely the result of the influences brought to bear upon it by the external world, then we should expect just such changes as we find here.

If we accept these changes as the result of environment, complicated it may be by other conditions, but still the result of environment, then it becomes a matter of the first importance to determine the length of time during which these changes have been going on. This, if it can be done, will serve to give us a measure of the rate at which organic life can accommodate itself to new conditions. Not that this measure will have a high degree of certainty, or will be applicable to all organic forms; we must, however, value anything which approximates a determination of the rate of change which a modification of conditions can bring about.

I. The Conditions of the Formation of Caverns.

In order to understand the limitation of cavern life, it is necessary for us to see clearly the conditions which make this life possible, and the horizontal and vertical extension of these conditions.

The first point is to determine what makes caverns possible. Only a very small part of the earth's surface presents conditions favorable to the existence of caverns, so we are justified in the conclusion that the conditions determining their formation are definite and limited. More than this, we find in many countries caverns which have become closed, or are rapidly closing, so that we may reasonably conclude that the conditions which favor their formation may exist at one time and pass away at another.

We will leave aside the caverns sometimes formed in cooling lava streams by the fluid interior of the mass sinking below the solidified crust. There is but a small amount of cavern region where this class of facts is possible; moreover, such caverns are essentially superficial, and are rapidly destroyed as the friable lava wears away. Besides, these caverns are generally limited to regions which are desolate as long as the caverns continue to exist, and they therefore promise us little in the way of experiments on the variability of organic forms.

The ordinary type of caverns, and that to which we are to give our attention, are the product of the action by water, aided, it may be, by sundry other minor causes. There are two distinct divisions of water worn caverns, those formed by the sea, and those formed by fresh water in the form of subterranean streams. Caverns of the first named class, though common enough, are for our investigation quite unimportant. Sea waters having little solvent power, the caves they form are generally quite shallow, rarely attaining great depth, and generally opening broadly to day. It is very rarely the case that marine caves have the depth necessary to enable them long to survive after the sea has ceased its excavation. Along the whole Atlantic coast, from Nova Scotia to Mexico, I do not know of a single cavern deep enough to give darkness, and above the present level of the sea. The only marine caves on the American coast of any considerable depth personally known to me, are on the Magdalen Islands in the Gulf of St. Lawrence, but I do not know at that

point of the existence of a single cave above the tide level. So far from caves being evidences of marine action, it is a safe statement that their occurrence in any district may generally be taken as evidence of long continued immunity from depression below the sea.

Taking the geological limitation of caverns, we notice at once that they are practically confined to limestone districts. When they occur in sandstone regions they are generally limited to narrow rifts that practically afford no sufficient field for cavern life. In a few cases I have found these sandstone caves enlarged by the occupancy of wild animals. Bears especially, and to a certain extent other animals often serve to enlarge caverns by rubbing against their sides, carrying away considerable quantities of dust upon their bodies, and distributing it in their wandering as it is shaken from them by the bushes in their track. Throughout Kentucky, in the regions of the carboniferous sandstone and the Waverly sandstone, we have thousands of shallow depressions commonly called "rock houses," caused by the more rapid recession of the base than the summit of a cliff; but, while the area of these chambers is often considerable, I have never, in the hundreds I have visited, seen a single case in which they were prolonged into true caverns, or had any part of their area beyond the reach of daylight. In fact, we cannot regard these shallow caves as giving us either the darkness or the uniform temperature essential to the development of the peculiar species of cavern animals.

The whole of the true caverns of the Mississippi valley, so far as I have been able to ascertain, lie within the limestone regions of that valley. The limestones of the Cincinnati group, especially the upper hundred feet, contain a few of these; they are all very shallow, and I have grave doubts whether, in a single case, they extend much beyond the light of day. Their channels are so narrow that the water floods sweep them as with a besom, driving out all the life that might attempt a lodgment there. When the streams cutting deeper into the rock leave the cavern quite dry, their walls are so feeble that they rapidly become closed with rubbish. I have never yet found a cavern in this series of rocks with a surface which did not bear the impression of being stream swept. It is only when we get into the massive limestone which lies just below the coal that we find true caverns on an extended scale. Here we find a marvelous development of such structures. Within the State of Kentucky there are not far from eight thousand square miles where the carboniferous limestone lies in positions suitable for the production of caves. In this region the limestone varies in thickness from a few feet to three hundred feet or more; it generally exceeds one hundred feet, and may be safely averaged at one hundred and fifty feet. Whenever we have this rock between the surface and the drainage level all the small streams at once desert the surface, and only the considerable rivers find the light of day. We may journey for fifty miles or more in the wet season without crossing running water; when we find it at all it is in the shape of a considerable river whose waters with nearly unvarying temperature in all seasons find their way into its bed through arches at the level of the stream. These arches lead us into caverns which rise stage on stage into the region on either side of the river. On the surface we find hills and the similitude of stream channels arranged as in ordinary countries, the valleys branching as in those which are stream swept, but there are no channels; only in the bottom of the valleys, be they great or small, a great number of more or less circular depressions, each usually with a pit leading down into the caverns below. Over most of this country these pits will average about one hundred to the square

mile; each is the entrance to a cavern channel, and by their numbers they enable us to estimate the extent of the ramifications of the caves beneath. There is no doubt that the aggregate length of the channels accessible to water is many tens of thousands of miles in Kentucky. I am inclined to think that the truth would not be overstated if we say that there are at least one thousand miles of open water channel beneath the surface of the carboniferous limestone belt in Kentucky. Owing to the rapid rate of the down cutting of these channels, and the massive nature of their walls, they remain open for a surprising length of time, and are so deep that they are rarely swept clean by the floods of the rainy season. Generally there are several levels to these channels, the upper of which have long since been abandoned by the water. These streams gather themselves together as above ground, and the channels soon become excavated into broad ways or caverns accessible to animals of any size, provided an opening is broken to the surface. Although this limestone is singularly massive and homogeneous, it yet varies somewhat in its various beds. A more resisting bed holds the streams in one level for a long time, and this makes a tier or floor of caverns. When the resisting bed is penetrated, as it generally is, by some stream passing from above, the water begins to excavate another floor, and that above is abandoned to the forces which tend to close it. When much water oozes into these stream-deserted caves, bringing with it materials to form stalactitic masses, we have forces which tend to close the cave, and often accomplish that work. There are channels in the Mammoth Cave which are far gone to destruction by this process, and some which have doubtless been entirely destroyed by this action. Most usually, however, the process of excavation goes on widening the cavern until the roof fails to sustain the weight, and we have great falls of stone tending to block the road of the stream and compel it to work another way. After being abandoned we sometimes find these caverns lasting for an extremely long time without change. The upper levels of the Mammoth Cave have doubtless remained substantially unchanged for hundreds of thousands of years. Stalactitic matter is kept from forming by the impervious roof, and by the small amount of limestone between the top of the cavern and the soil, which does not admit of the water becoming very much charged with lime in its passage to this level.

As the streams gather force they begin to use moving pebbles as teeth for their cutting work, and thus pass more rapidly from stage to stage. It may be in part to this that we owe the fact that the lower chambers in the series are quite generally smaller than the upper chambers. Most of the grand avenues known to me are on the upper level of the cavern work.

The most surprising features in the architecture of caverns are the great "domes" or wells which often pass at one leap from the uppermost to the lowermost level of the caves. These are uniformly caused by streams, which by one cause or another secure in the beginning, while they flowed on the upper level, a vertical descent of greater or less height. Often it is a "sink hole" from the open air, which begins the vertical channel. As soon as a beginning is made, each additional foot of depth adds to the force of the torrent. The sandstone above and the flint beds of the limestone itself, furnish a plentiful supply of pebbles to give energy to the cutting action. Thus we see these caverns in their fullest development consist of the following elements: the tubes leading from the sink hole or funnels of the surface to the gathering bed or uppermost set of caverns; then a succession of levels of caves connected by vertical shafts formed as before described, or by breaks in

the floors. At the end of this series comes the stream which represents the base of the drainage of the country.[1]

With this sketch of the essential elements of structure of the caverns, it now only remains for us to complete our view of their development by an examination of certain features in their history. In the first place it is important to notice that the development of caverns depends in a great degree on the massiveness of the limestone beds; when these limestones are thin-bedded, or intershafted at many points with sandstones or clays, the essential conditions for the formation of large caverns are wanting. Now whence comes the massiveness of this limestone? This feature of massiveness is not uncommon among metamorphic limestones, like those of Carrara, or the limestones of the Cambrian series in this country, but among our unaltered limestones this uniformity is rather peculiar. I am somewhat inclined to attribute this massiveness to the nature of the organic life which secured their deposition. Beds of molluscous fossils are very apt to be much divided horizontally, while those composed of crinoidal remains are apt to be more soldered together. A possible explanation of this may be found in the fact that crinoid stems evidently remained standing on their roots after the head had died, so that when the stems are planted each a few inches apart, with new ones constantly coming in between, there would be no interruption to the deposit until the crinoidal life was ended.

The enormous area of crinoidal limestones in Kentucky, at the time of the carboniferous limestone, leads us to suppose that the water was warm, and richly charged with carbonate of lime. No other form of life, not even corals, could take such large quantities of lime from the water over so great an area at the same time. It is impossible to suppose that this deposit was deep water, for the molluscan forms are quite large; and it is quite as difficult to believe that land was near by, for the amount of silt is not large; yet it is required for us to suppose large areas of land feeding the sea with the wash of its limestone rocks, currents bearing the sea water charged with this carbonate of lime, and a perfect immunity from the deposition of sand.

Age of the Caverns.

The fact that there is a complete and very detailed stream topography, or contours formed by running water, on the surface of the overlying sandstone, and on the uppermost beds of the limestone, shows that the smaller streams did not always run in subterranean ways, but pursued their surface channels until the main rivers had cut well down into the limestone, so there could have been no great system of caverns until this down cutting had brought Green River into the limestone. It is therefore only necessary for us to compute the time which has elapsed since the process began, in order to determine the duration of the cavern system in this section. Data for making this computation in the most satis-

[1] Of the diagrams, Pl. XII, fig. 1 represents the general system of the limestone caves in their fullest development; fig. 2 the sandstone caverns. Only three sink holes are indicated and only half a dozen chambers. In Edmonson County alone there are probably over four thousand sink holes and over five hundred open caverns.

A, A. Sandstone above limestone, showing ordinary topography.

B, B. "Sink holes," that in the sandstone being unusual in that kind of rock.

C, C, C. "Domes" below large "sink holes."

D, D. Upper level of caverns being the first formed.

F. Cavern filling with stalactitic deposit.

G. Lowest level of caverns opening at level of river.

H, H. Masses of pebbles, forming, when put in motion by falling water, a powerful cutting engine.

factory way are wanting, but there are certain inferences which may bring us very near the truth, or at least enable us to fix a superior limit for their duration.

The computations which have been made as to the amount of wear over the surface of the Mississippi valley, have shown that about one foot in each six thousand years passes away from the surface of the whole valley; as this quantity is determined by the amount of solid matter passing into the Gulf of Mexico during a given time, it is of course averaged over the whole basin. But it is a well known fact that the Ohio valley furnishes by far the most considerable amount of sediment in proportion to its area of any of the large rivers tributary to the main stream. Its volume of water is actually rather larger than that furnished by the Missouri, though the area whence it comes is not quite half as large, so that if the amount of sediment be proportionally as large, the amount of erosion should be about doubly as great. This estimate of one foot of erosion in every three thousand years is doubtless not far from the truth at the present time; but as the waste during the more ancient forest-clad state was somewhat less, we will suppose the slower rate of one foot in six thousand years. It must be noticed that the stream beds of any country must cut down more rapidly than the general surface of the country they drain, and the difference in these rates of cutting is approximately measured by the difference in the level of the river beds and the upland country. Now as the stream beds occupy not over the twentieth part of the area in this country, they must cut down much more rapidly than the table land about them. My own impression is that their cutting rate is at present three or four times as fast in this particular section, but we will not make any allowance for this difference, letting it go as a means of making the assurance of the average rate of one foot in six thousand years the safer as a basis for calculation. On this basis we have next to consider the thickness cut through since the streams struck the limestone. At the Mammoth Cave we may estimate this at two hundred feet. As we go to the east the level of the limestone rises rather more rapidly than the beds of the streams, so that we find that about three hundred feet is the maximum height of the limestone above the stream beds. At the rate of one foot in six thousand years we get about two million years as the maximum time during which these caverns could have existed. If we apply the correction for the difference in the rate of cutting of stream bed and upland, we shall have to shorten this time to less than a million years, possibly to seven hundred and fifty thousand years.

Although not exact, a defect common to all geological time ratios, these calculations have for us great value, as they serve to show that the caverns of this district are of comparatively modern origin. It is not reasonable to suppose that a million of years can carry us much further into the past than the early part of the pliocene period, the latest of the complete divisions of the tertiary period in our northern section. If, then, these caverns have not inherited their life from preëxistent caves which have since been entirely destroyed, then we may suppose that they will serve as measures of the rate of change in organic life in a very satisfactory way. It is impossible to discuss this question in detail at the present time, but even with our imperfect knowledge some hints may be had towards its solution. The sandstone series above the limestone furnishes no caverns, and as it has a thickness of at least three thousand feet, and wears rather slowly, there could have been no succession there. The only possibility would have been through the original extension of the carboniferous limestone over the region now underlaid by the devonian series, including the Wa-

verly beds, and possibly over the Cincinnati series as well. If we assume that one foot of beds disappears every six thousand years, then we must suppose that several thousand feet of strata have been removed from the top of the Cincinnati axis, unless we consider that this axis has been repeatedly under water since the time of its elevation. My own opinion is that this axis has not been constantly above the water line, but that it has been subjected to alternating elevation and subsidence ever since the calciferous sandstone was formed. During the formation of the subcarboniferous limestone it was probably elevated, inasmuch as this limestone seems both on the east and west to grow thinner as we approach it. During the carboniferous period, or the time when the true coal beds were being laid down it seems more likely that it was again, from time to time, submerged. These coal beds, or some later formation, must have covered it and furnished materials for subsequent wear. If this view be correct, then we cannot look for a long succession of caves while the carboniferous limestone was wearing away from its position a thousand feet or more above the top of the Cincinnati axis.

On the whole, it seems probable that while some caverns may have existed in the Mississippi valley long before the tertiary period, their great development and the consequent chances of organic life finding its way into cavern conditions is a very recent event.

In this connection there is a question of considerable moment to be discussed. It is evident that the extension of glacial conditions over any region must absolutely arrest the succession of development of any cavern species. To them migration must be regarded as impossible. The temperature brought by ice, even if we can suppose that it did not fill the caverns; the exclusion of supplies of organic matter from the surface, and the interruption of drainage, must make the continuance of this life impossible. The question therefore arises whether the last glacial period extended its action over this region. On that point I can give a very decided negative answer. A most careful search has failed to show the slightest trace of glacial action on this region. I am inclined to think it likely that some glacial periods anterior to the tertiary may have extended their ice sheet as far south as this, but am quite satisfied that the ice periods which have left their distinct record in the north, never operated here.[1] Inasmuch, however, as the southern border of the ice sheet was not over two hundred miles to the north, it is evident that the most important general effects on climate must have been produced, the species now living here must have been driven further south by many hundred miles. It must, in fact, have brought a boreal, if not an arctic, fauna into their region. When we consider the essentially close relation between the life within and the life without the caves, we become convinced that the cavern species are derived from the present fauna, and could not have been the descendants of an arctic assemblage of species. In the case of the Astacidæ, for instance, we must suppose either of two things, that the cavern form descended from the outer form before the glacial period, or after that time. In the latter case we are entitled to suppose that the outside species migrated southward during the glacial period, and returned after its close.

Considering the whole relations of the species found without and within the caverns about the Mammoth Cave, we are led to the conclusion that the dozen cavern forms which

[1] In a succeeding memoir of this series I shall endeavor to show that we had at Big Bone Lick, in Kentucky, a locality about one hundred miles north of the Mammoth Cave, but not more than forty miles to the north of the caves of Carter County, an assemblage of life at the close of the glacial period distinctly indicating arctic conditions; this point being about the northernmost station for plants and animals during the fullest extension of the ice sheet.

are related to outer species more or less closely, have been derived from those outer forms since the present assemblage of life in that district was constituted. This conclusion is the more necessary when we come to consider the assemblage of life in the caverns in Indiana, Wyandot Cave, etc. Here we are close to the border of the glacial sheet, and quite within its influence, if not at times actually beneath its bed, yet the relations to the external life are here the same as about the more southern caves.

On another important point we have much light from the study of cavern life. A number of these cavern forms are found on different sides of the Ohio River. Now it is clearly impossible that these forms could have sprung from a common centre, they must have originated at several points. The blind cray fish, the several insects which are common to the several regions, must have originated in each and all of them. The Ohio River, with its wide intervening non-cavernous valley, would be a very formidable barrier for them to traverse, and we have no right to presume that they passed it.

If the organic forms inhabiting these caverns had been the product of long continued change, begun in distant geological periods, then we should expect this assemblage of cavern species to present something of the same general contrast to the life without the cave that is shown in the forms of any two widely separated geological formations plus the special changes which come from the peculiar conditions of caverns. What we find, in fact, is a fauna which is singularly like that of the outer world, and wherein every important difference is probably connected with the peculiar conditions in which it has developed. This absence of all marks of difference, such as would have existed had the connection between the inner and outer life been remote, leads us to no very positive conclusion, though it suggests some interesting possibilities.

In the first place, if these caverns have been in existence for the greater part of the tertiary period, then, either the insect fauna of their neighborhood has been much what it is at present during the whole time of their existence, or the present assemblage of species belongs to the colonization which has taken place since the last great faunal change. Then if we determine that these cavern species have not long inhabited their present abodes, are we to conclude that some agent, such as glaciation, has killed off the earlier cavern forms, prevented as they are from the migrations which save the external species; or is it that organic forms being introduced to these unnatural conditions can only survive for a certain time, their generation becoming enfeebled in the course of ages and passing away, so that whenever the constant supply of recruits from the outer world is broken, the given form quickly perishes?

These hypotheses are not proposed as dilemmas, but as hints to an important investigation. Let the life of certain caverns be taken, some from within and some from without the region of glacial action; then with the certainty that in the one case the life has been interrupted by ice action, and the reasonable certainty that no such interruption has befallen the life in the other set of caves, we shall be a position, by comparing these assemblages of forms, to come to some opinion on this important question.

The facts observable in the case of the cray fish of our caverns, seem to lead us to the conclusion, which in fact seems probable on other grounds, that the cavern species are being continually reinforced by the infusion of fresh blood from the outside. We find, along with the white and sightless forms, some that are white but with eyes; others with eyes and some color; still others that are quite like the external species. It would be a great addition to

our knowledge of the relations of organic species if it could be definitely determined that these whitened, sightless cavern forms could or could not breed with the ordinary external varieties.

To sum up the conclusions which may be drawn from the discussion of the antiquity of caverns and cavern life, we may say that these structures are probably of no great age, and that the life within them gives no evidence of great antiquity in its origin, and that it is quite within the evidence to suppose that most of the species now living within the caves are pretty constantly reinforced from without.

In closing, it may be remarked that this continent presents an admirable field for the study of the whole range of questions connected with the organic life of caverns. In New York State we have caves which have received the full force of glacial action as far as any caves can. In the Ohio valley, a vast system that has perhaps received the secondary effect of ice, and possibly been covered by ice in remote times, but not during the last glacial period. In Mexico and Cuba we have caverns which have certainly never been ice covered; so that any phase of the question can be easily examined. The Geological Survey of Kentucky has already examined the faunæ of about fifty caverns. The animals from the caves are now in the hands of Professors Packard and Putnam, and the gentlemen they have associated with themselves in their researches. On their investigation it is hoped that their special researches may throw important light on the history of these forms. The conclusions which I believe warranted by the considerations already adduced, may be summed up as follows: —

1. The extensive development of caverns in the Ohio valley is probably a comparatively recent phenomenon, not dating further back than the latest tertiary period.

2. It is doubtful whether there has been any extensive development of cavern life in this region before these caverns of the sub-carboniferous limestone began to be excavated.

3. The general character of this cavern life points to the conclusion that it has been derived from the present fauna.

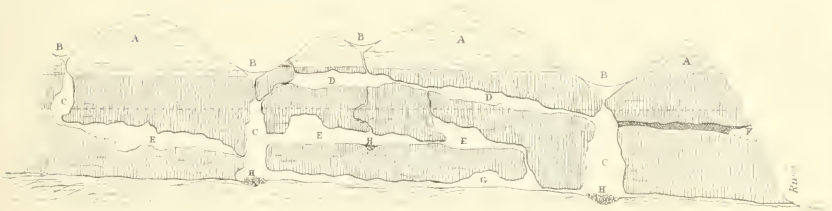
4. The glacial period, though it did not extend the ice sheet over this cavern region, must have so profoundly affected the climatal conditions that the external life could not have held its place here in the shape we now find it, but must have been replaced by some more arctic assemblage of species. Under the circumstances, it is reasonable to suppose that most, if not all, the species found in these caves have been introduced since the glacial period.

5. We are also warranted by the facts in supposing that there is a continued infusion of blood from the outer species taking place; some of the forms showing the stages of a continual transition from the outer to the inner form.[1]

[1] I propose hereafter to discuss the bearings of all the facts derived from cavern life on the doctrine of evolution, and shall then consider the special questions connected with the fishes of the cave, the question of their marine origin, etc.

Diagramatic Section illustrating the structure of Rock Houses or Sandstone Caves

At many points these shallow caverns attain very great size, say 100 ft front and 60 ft. deep



A A A *Sandstone and limestone showing ordinary topography*

B B B B *Sink holes*

C C C *Domes below large Sink holes*

D D *Upper line of caverns first formed*

E E E *Lower line of Caverns*

F *Cavern filled with Stalactite*

G *Lowest line of Caverns opening below line of river*

H H H *Masses of pebbles*

XIII. Prodrome of a Monograph of the Tabanidæ of the United States. Part I. The Genera Pangonia, Chrysops, Silvius, Hæmatopota, Diabasis. By C. R. Osten Sacken.

Read January 6, 1875.

THE purpose of the present paper is to pave the way for a future monograph of the *Tabanidæ* of the United States. In a family as difficult as the present, a preparatory paper of this kind does good service in encouraging collectors and disclosing the doubtful points which can be solved only by an increase of material.

A conscientious monograph requires, besides specific descriptions, a thorough investigation of the generic and family characters, based upon the knowledge of the generic forms of the whole world. My present purpose being merely the discrimination of the species, I refer, for the definition of the genera, to the existing works on the subject. I would especially recommend the chapter on *Tabanidæ* in Dr. Loew's large work: *Die Diptern-Fauna Süd-Africa's*, in which a critical review of the whole family and of all the adopted genera is given. A similar review will be found in Dr. Schiner's Diptera of the Novara expedition.

The types of all the descriptions given below are to be found in the Museum of Comparative Zoology, in Cambridge, Mass., unless otherwise mentioned.

The following tabular arrangement has no other claims than to embrace the genera and species contained in the present paper.

TABULAR ARRANGEMENT OF THE NORTH AMERICAN GENERA OF TABANIDÆ.

1.	Hind tibiæ with spurs at the tip. Ocelli in most cases present.	2.
	Hind tibiæ without spurs; no ocelli	4.
2.	Face and front (♀) without tubercles or callosities	**Pangonia.**
	Front (♀) provided with a tubercle or callosity	3.
3.	Second antennal joint almost as long, or as long, as the first; wings with a black or brown design	**Chrysops.**
	Second antennal joint very much shorter than the first; wings without any spots	**Silvius.**
4.	Front (♀) much longer than broad; frontal tubercle (when present) not transverse	**Tabanus.** / **Diabasis.**
	Front (♀) as broad as it is long, or broader; frontal tubercle transverse (about four times broader than long)	**Hæmatopota.**

PANGONIA.

The described species from the United States (with the exception of *P. fusiformis* Walk.) may be tabulated as follows: —

1.	Proboscis longer than the whole body	**macroglossa** Westw.
	Proboscis not much longer than the head.	2.

2.	First posterior cell closed	**incisa** Wied.
	First posterior cell open	3.
3.	Antennæ dark	4.
	Antennæ light reddish or yellow	5.
4.	Hind borders of abdominal segments with gray hairs	**rasa** Loew.
	Hind borders of abdominal segments with golden-yellow hairs	**tranquilla** n. sp.
5.	Wings subhyaline, with a yellow stigma	**pigra** n. sp.
	Wings brownish, except the base and a space on the hind margin, which are hyaline	**chrysocoma** n. sp.

Of these six species, I know only those described by me, and the one described by Mr. Loew. The seventh species, *P. fusiformis* Walker, Dipt. Saund., p. 19, I could not insert in the table, on account of the insufficiency of the description. The four species described below, as well as *P. incisa* Wield. are provided with ocelli; *P. macroglossa* Westw., has none.

According to a manuscript note of Dr. LeBaron on a specimen of *P. rasa* Lw. which I have from him, the eyes of this species are immaculate. This is the only statement in my possession concerning the coloration of the eyes in this genus.

1. Pangonia rasa.

Pangonia rasa Loew., Centur., VIII, 7.

Antennæ blackish-brown, two basal joints reddish; hind margins of the abdominal segments beset with grayish hairs; wings sub-hyaline, stigma brown.

♂. Thorax blackish-brown above, and with brownish hairs; gray on the sides; abdomen brownish.

♀. Thorax blackish-gray above, with short, appressed, white hairs; gray on the sides; abdomen brownish or blackish.

Length, 10–12 mm.

Face and front gray, with a slight yellowish tinge; palpi reddish, beset with black hair; antennæ: two basal joints and extreme base of the third dark reddish, the former beset with black hair; the remainder of the third segment dark brown. Proboscis a little longer than the head. Thorax (♂) dull brownish-black, with a brownish gray-pollen, forming two indistinct longitudinal lines; a side view shows, in front of the scutellum, two spots covered with bluish-gray pollen; sides of the thorax and breast gray; the dorsum is clothed with a brownish, erect pubescence: its sides and the pleuræ with long grayish hairs. In the ♀ the thorax is more grayish, with a faint brownish middle line and two lateral stripes of the same color; the dorsum is clothed with short, appressed white hairs; the pleuræ with long, soft hairs of the same color. Scutellum brown in the middle, hind margin gray. Abdomen more or less dark brown; two basal joints often blackish in the middle, hind borders of the segments paler, and beset with whitish hairs. Legs reddish-brown. Wings subhyaline, stigma brownish; distal half of the marginal cell faintly tinged with brownish; posterior cells open.

Hab. Illinois (LeBaron); Wisconsin (Kennicott); Manlius, N. Y. (J. H. Comstock). Two male and three female specimens.

2. Pangonia tranquilla n. sp.

♂, ♀. Brownish-black, sides of abdomen and base of venter reddish, abdominal segments beset with golden-yellow hairs on the posterior borders; legs brown, antennæ black, wings tinged with brownish.
Body 12, wings 10½ millim. long.

Head yellowish-gray, beset with yellowish-gray hairs; palpi (♀) brown beset with black hairs, palpi (♂) narrow, brownish-black, grayish-pollinose at the base, sometimes reddish at tip; proboscis somewhat longer than the head, black with well developed labella; antennæ black; basal joint slightly grayish-pollinose and beset with black hairs. Thorax brownish, with gray pollen and beset with yellowish hairs; in the ♂ the thoracic dorsum shows three brown longitudinal lines on grayish ground; scutellum brownish, posterior margin grayish-pollinose. Abdomen blackish-brown; three basal segments reddish-yellow on the sides and on a narrow margin posteriorly; the following segments have only a trace of yellowish-red on the sides; all the segments with a fringe of golden-yellow hairs on the posterior margin: venter; basal segments reddish-yellow, the following ones black. Legs black, knees somewhat paler. Wings with a brownish tinge, which is more saturate and somewhat yellowish in the region of the stigma and along the anterior margin; no stump of a vein on the fork of the third vein; posterior cells open.

Hab. Massachusetts (Mr. Sanborn); White Mts. (B. P. Mann); also in the Middle States (Entom. Soc. Phil.); Canada (Belanger). One male and two females.

3. Pangonia pigra n. sp.

♂, ♀. Brownish-yellow, beset with golden-yellow hairs; antennæ and legs reddish-yellow. Wings hyaline, stigma yellow.
Body 11–11½, wings 10½ millim. long.

Female. Head yellowish-gray; palpi reddish-yellow, beset at the base with pale yellow hairs; antennæ reddish, basal joints yellowish-pollinose and beset with pale hairs; proboscis somewhat shorter than the head, comparatively stout, with large labella. Thorax fulvous, with short appressed yellow hairs above, altogether covering the blackish stripes on the disc; longer, paler hairs on the sides and below. Scutellum fulvous, more or less blackish in the middle. Abdomen brownish-yellow, with appressed golden-yellow hairs, especially apparent as a fringe on the posterior margins of the segments. Legs brownish-yellow. Wings nearly hyaline, slightly grayish; yellowish at base and along the costal margin, inside of the first longitudinal vein; stigma large, elongate, saturate yellow; no stump on the fork of the third vein; posterior cells open.

A male from the Museum of the Entomological Society in Philadelphia has the thoracic dorsum blackish, with two reddish lines separating the usual stripes; the scutellum is blackish in the middle; the brownish-red abdomen has, besides the appressed golden-yellow hairs, which are but little apparent, some short, erect blackish hairs, especially visible on the sides.

Hab. Bee Spring, Kentucky, in June (Sanborn); another specimen from the State of New York. Two females, one male.

4. Pangonia chrysocoma n. sp.

Antennæ reddish; proboscis very short; wings, brownish anteriorly, hyaline at the root and posteriorly.

♂. Thorax and abdomen dark brown, the latter with the hind margins of the segments yellowish and beset with golden-yellow hairs.

♀. Thorax and abdomen pale yellow, clothed with an appressed, shining, golden-yellow pubescence.

Length, ♂ 10 mm.; ♀ 14 mm.

Male. Antennæ reddish, two basal joints beset with long, black hair; face brownish, clothed with yellowish-brown pollen. Thorax blackish-brown, with a yellowish pubescence; pleuræ grayish-pollinose. Abdomen blackish-brown, with narrow yellow bands, clothed with a golden-yellow pubescence, along the incisures of the segments. Legs reddish-yellow, tips of tarsi brownish. Wings: root hyaline, with pallid veins; a brown cloud occupies the proximal and anterior part of the wings, filling the two basal, the marginal, the greater portion of the first submarginal, and the proximal half of the first posterior cells; also invading the proximal ends of the discal and the fifth posterior cells; anal angle and anal cell also tinged with brown in the middle; costal cell and stigma brownish-ferruginous; second submarginal cell grayish; the remainder of the wing, between the ends of the third and fifth veins, along the hind margin, including the larger portion of the discal cell, hyaline.

Female. Head pale yellow, opaque; front very broad, broader anteriorly than posteriorly; eyes comparatively small; a triangular space above the antennæ is destitute of pollen, and hence more shining; below the antennæ, down to the palpi, there is a convex, trapezoidal reddish-yellow, shining space, limited by deep grooves. Antennæ yellow, third joint reddish. Palpi yellow, with short, black hairs. Proboscis extending but little beyond the palpi, yellow, lips large. Cheeks clothed with a very soft, whitish pubescence. Thorax somewhat reddish on the disc, with a faint trace of a longitudinal dark line, otherwise uniformly yellowish, densely clothed with appressed pale yellow, shining hairs. The abdominal segments above show some traces of brownish at the base; otherwise the abdomen is uniformly yellowish, with a dense, appressed, pale golden-yellow, shining pubescence. Halteres and legs yellow. Wings: a pale brown cloud of a rather indefinite outline occupies the two basal, marginal and submarginal cells, somewhat encroaching upon the base of the first posterior, of the discal and slightly upon the fifth posterior cells; the root of the wing is hyaline; the costal cells, the base of the marginal cell and the whole posterior half of the wing are impure hyaline; a slight brownish cloud in the axillary corner of the wing. Stigma and its environs tinged with yellow. Base of the second submarginal cell rather acute; no stump. All posterior cells open.

Hab. Middle States; Trenton Falls, N. Y.; Delaware. (A male in the Museum of the Ent. Soc. Philad.; a female in Mus. Comp. Zool., Cambridge, Mass.)

Observation. The proboscis of this species is unusually short for a Pangonia; the basal division of the third joint is stout, without any vestige of an angular projection; the (♀) front is three times as broad as in the three preceding species; the head is flattened, etc.[1]

[1] It may be useful to reproduce here the rather inaccessible description of *P. macroglossa* Westw. (Lond. and Edinb. Philos. Magaz. 1835).

Pangonia macroglossa Westw.—Pallide fusco pubescens; facie alba, (ocellis *O*), thorace vittis duabus longitudinalibus in medio, lateribus et macula utrinque basin versus alarum albis, abdomine piceo, segmento primo fulvo marginato, 2^do^ et 4^to^ albo marginato, 3^tio^ rufo marginato, reliquis fusco marginatis; alis basi et a costam late infumatis; pedibus testaceis.—Long. corp. lin. $8\frac{3}{4}$ long.; prob. lin. 15. Exp. alar. lin. 10. Hab. in Georgia.

CHRYSOPS.

The great difference in the coloring of the body, existing between the males and the females of Chrysops and the comparative rarity of the former in collections, compelled me to adopt the plan of basing this monographic essay principally on the female specimens. Thus the analytical table is drawn for females only; in the diagnoses and descriptions, the females are introduced first; short, comparative descriptions of the males are added, wherever they are known. Although it seems easy enough to refer the males to the proper females, by the comparison of the design on the wings, and especially on their distal portion, which is usually identical in both sexes, I would hesitate to place an absolute reliance on such identifications, until they were confirmed by actual observation, that is, by a capture of both sexes together in the same locality. Such captures I have been able to make in a very few cases only, and for this reason most of the females described below are accompanied by probable, but nevertheless hypothetical, males.

For further details on the genus Chrysops, I refer to Dr. Loew's paper on the European species (Verh. Zool. Bot. Gesellsch. 1858, p. 613). I would only add a single remark concerning a character not mentioned by him, namely, the coloring of the eyes in living specimens. All the American species of Chrysops which I had the opportunity to observe alive, have the eyes colored very nearly in the same manner (fig. 1); that is, the ground-color being green, there is along the occipital margin a dark purple border with an indentation in the middle; on the opposite or frontal margin, there are three purple spots; and between the two, in the middle of the eye, there is a fourth spot, usually arrow-shaped, the shaft of which reaches upwards and ends in the occipital border (*C. excitans*). All the species observed by me show only modifications of this design. Sometimes the occipital border, instead of being notched, is interrupted in the middle; or the arrow-head is connected on one side with the middle one of the three spots near the frontal margin (*C. plangens*); or the shaft is interrupted above (*C. niger*), or altogether wanting; in the latter case, the arrow-shaped spot is sometimes replaced by a more or less rounded one, and when this round spot is connected with the lateral spot near it (fig. 2, *C. fugax*) the pattern appears considerably modified, although it belongs to the same original type. Slight variations occur in the same species, and my observations have not been sufficiently numerous to enable me to characterize the eyes of each species separately. *C. æstuans*, *montanus*, *hilaris*, *excitans*, *delicatulus*, *niger*, *univittatus*, *plangens* and *fugax* have their eyes colored on the above described pattern with the indicated modifications. The male specimens show the same design, only modified by the lengthening of its upper half and the shortening of the lower one, the former having the larger and the latter the smaller facets. The only exceptional pattern, which I have hitherto observed, is that of the eyes of *C. flavidus* Wied, a species very different in its general appearance and coloring from the typical Chrysops. (See fig. 3.) In this pattern the central spot (the arrow-head,) which is the most persistent feature in the eyes of the first pattern, has disappeared.

Fig. 1. Fig. 2. Fig. 3.

A few words only will be necessary in explanation of the terms used by me in the following descriptions. I call *apical spot* every infuscation of the portion of the wing

beyond the usual crossband, whether this infuscation is connected with the crossband or separated from it. The hyaline interval between the crossband and the apical spot, I have usually called the *hyaline triangle*.

In identifying species of Chrysops, the principal attention should be paid to the design of the wings. It is characteristic of the species and, at the same time, remarkably constant within the same species. It also helps to refer the male specimens to their females, however different in coloring the sexes may be. The wings of the male are usually somewhat darker on their proximal half; the infuscation of the two basal cells reaches farther towards the distal end of these cells, the anal cell and anal angle often have a brownish tinge, which may not exist in the female. But in the distal half of the wing, especially in the shape of the apical spot and of the hyaline triangle between it and the crossband, the resemblance between the sexes is, in most cases, much greater. The coloring of the antennæ and of the legs is very variable within the same species and in the same sex, and not to be relied upon. The relative extent of black and reddish on the abdomen is also very variable in the same species; often the whole appearance of a specimen is changed by an extensive prevalence of the one or the other color. The coloring of the wings is the only safe guide through all these difficulties.

The insufficiency of most of the descriptions by Walker and Macquart has compelled me, in many cases, to quote their descriptions as doubtful synonyms of my supposed new species. As I give detailed and I hope sufficiently clear, descriptions of all the species, I trust that in most cases there will be but little doubt as to the species I mean to describe. The other question, that of the names to be given to these species, is comparatively of a secondary importance, and can be settled only through the comparison of the original types of the earlier descriptions in London and Paris.

I describe in this paper twenty-three species of Chrysops distributed over the area contained between the District of Columbia, Wisconsin and Canada (besides *C. atropos*, from Florida); no doubt many more species will be discovered. The whole of Europe north of the Alps possesses only twelve species; the southern peninsulas have four species more; total for Europe sixteen species. Among the twenty-four North American species here described *seven* have no apical spot, that is the whole apical portion of the wing is hyaline. Of the sixteen European species not a single one belongs to this category. Four European species have a hyaline or subhyaline spot in the middle of the crossband; no such species have been discovered yet in the Atlantic basin of North America; but I have seen one or two from California. Such are the results of a comparison of both faunas, based on the descriptions of the European species. A comparison of specimens would probably disclose still other curious analogies or differences; unfortunately I have specimens of only two European species before me.

ANALYTICAL TABLE OF THE SPECIES (CONSTRUCTED FOR FEMALE SPECIMENS ONLY).

1.	The apex of the wing, beyond the crossband, is hyaline	2.
	The apex of the wing, beyond the crossband, is more or less infuscated	8.
2.	The whole wing, except the apex, is black, fading into dark-gray posteriorly	**1. atropos** n. sp.
	The whole wing, besides the apex, is not black	3.

3. Both basal cells are infuscated on their proximal half. . . . . 4.
   Second basal cell hyaline; face ferruginous in the middle . . . . . **7. niger** Macq.

4. Abdomen marked with more or less yellow on the sides . . . . . 5.
   Abdomen altogether black . . . . . 6.

5. Abdominal segments with narrow gray borders posteriorly; the yellow spots on the sides of the first two abdominal segments small . . . . . **6. sordidus** n. sp.
   Abdominal segments without any gray hind borders; the yellow spots on the sides of the abdomen usually large . . . . . **2. excitans** Walk.

6. Thorax with a conspicuous tuft of yellowish-ferruginous hairs on each side, in front of the wings . . . . . **5. celer** n. sp.
   Thorax with pale yellowish hairs on the sides . . . . . 7.

7. Fifth posterior cell filled out with brown at the proximal end; thorax with two rather distinct whitish lines anteriorly . . . . . **3. mitis** n. sp.
   Fifth posterior cell with a small hyaline spot at the proximal end; no distinct white lines on the thorax . . . . . **4. fugax** n. sp.

8. Whole body brownish-yellow; abdomen with a pale-brownish design . . . . **5. flavidus** Wied.
   Body more or less black (or at least with black longitudinal stripes on the abdomen) . . . . 9.

9. Both basal cells hyaline[1]. . . . . 10.
   First basal cell altogether, or to a considerable extent, infuscated . . . . . 17.

10. The apical spot consists of a narrow brown border along the costa, between the crossband and the apex; (distal half of the first submarginal cell, except at its extreme end, hyaline) . . . . 11.
    The apical spot is broad, and fills out a considerable portion of the distal half of the first submarginal cell . . . . . 13.

11. Crossband in the usual shape, not attenuated posteriorly . . . . . 12.
    Crossband attenuated posteriorly, the brown occupying but a small portion of the discal and fourth posterior cells . . . . . **10. delicatulus** n. sp.

12. A black triangle encroaches upon the yellow on each side of the ∧-shaped black spot on the second abdominal segment. . . . . **8. æstuans** v. d. Wulp.
    No black triangles on the sides of the ∧-shaped black spot on the second segment. **9. callidus** n. sp.

13. The hyaline triangle, between the apical spot and the crossband, stops short at the second longitudinal vein. . . . . 14.
    The hyaline triangle, etc., is prolonged beyond the second longitudinal vein, towards the costa . . 15.

14. Second and third abdominal segments black, with yellow hind margins, expanded into triangles in the middle; frontal callosity reddish . . . . . **11. pudicus** n. sp.
    Second and third abdominal segments yellow, with four broad longitudinal black lines, which are often broader than the intervening yellow spaces; frontal callosity black . . . **12. montanus** n. sp.

15. Abdomen dark brown, or black above, with a yellow longitudinal stripe, attenuated posteriorly, and two shorter and narrower stripes on each side . . . . . **23. obsoletus** Wied.
    Abdomen yellow above, with two small, converging black spots on the second segment; segments three and four black and yellow . . . . . 16.

16. The crossband reaches the posterior margin . . . . . **22. fallax** n. sp.
    The crossband does not quite reach the posterior margin, the fourth posterior cell not being quite filled out with brown . . . . . **21. hilaris** n. sp.

[1] The species referred to here have, in some instances, an inconsiderable infuscation at the proximal end of the first basal cell, while the species referred to No. 17 have this cell infuscated far beyond the middle. Between these alternatives, a doubt may arise in the following cases only.

C. montanus, which has the largest infuscation of the first basal cell, among all the species referred to No. 10.

C. frigidus, which has the smallest infuscation among the species referred to No. 17.

17. Body altogether gray or blackish . . . . . **24. plangens** Wied.
Body more or less marked with yellow . . . . . 18.

18. Face black, with the usual stripes of fulvous pollen . . . . . **14. frigidus** n. sp.
Face ferruginous in the middle . . . . . 19.

19. Apical spot large, reaching beyond the second submarginal cell, and invading the first posterior . 20.
The apical spot does not reach beyond the second submarginal cell . . . . . 22.

20. The hyaline space, between the crossband and the apical spot, is confined to a small triangle in the second and third posterior cells . . . . . **17. mœchus**[1] n. sp.
The hyaline space, etc., reaches across the first posterior cell . . . . . 21.

21. Abdomen with a broad, yellow, longitudinal stripe in the middle, enclosed between two blackish stripes . . . . . **16. univittatus** Macq.
Abdomen brown, with three brownish-yellow, often indistinct longitudinal stripes **18. morosus** n. sp.

22. Abdomen yellow, with four black stripes . . . . . 23.
Abdomen black, yellow on the sides, and with yellow triangles on the segments . . **13. indus** n. sp.

23. Frontal tubercle and scutellum reddish . . . . . **19. vittatus** Wied.
Frontal tubercle black; scutellum at the base, more or less blackish . . . . . **20. striatus** n. sp.

DESCRIPTION OF THE SPECIES.

A. The apical portion of the wing, beyond the crossband, is hyaline, without any distinct brown spot or brown border.

1. Chrysops atropos n. sp.

? *Chrysops divisus* Walker, List, etc., I, p. 204.

♀. Altogether black, wings tinged with black, except the apex, which is hyaline.

Length, 9–10 mm.

Female. Altogether black; a large, shining black, obtriangular surface occupies almost the whole face, showing each side a mammiform protuberance; streaks of fulvous pollen between this triangle and the black cheeks; pollen of the same color forms a narrow border along the facial orbit, round the root of the antennæ and on the sides of the front; the black, shining, frontal callosity is separated from the vertex by an opaque, brownish-pollinose crossband. Palpi black, brownish on the inside. Antennæ black, comparatively long, the first and second joints being longer than usual; the first somewhat incrassate. Thorax clothed with a very thin chocolate-brown pollen, hardly concealing the shining black color beneath; it is more dense anteriorly, where it forms two indistinct lines, abbreviated posteriorly, and more visible from a side view; (this thoracic pollen is very easily rubbed off). Pleuræ brownish. Abdomen with scattered whitish hairs toward the tip. First joint of middle and hind tarsi yellowish, except the tip, which is black; root of second joint likewise pale. Apical third of the wings hyaline; the remainder black, which color is most saturate along the costa; anal cell and the whole anal angle, grayish. The veins in the hyaline, apical portion of the wing are yellowish, especially the costal vein.

Hab. Florida (Wekiva River, in March, Prof. J. Wyman; Indian River, E. Palmer). Eighteen female specimens.

[1] This is the hypothetical female of *C. mœchus* ♂, described below.

The description of *C. divisus* Walker, seems to agree with this species, except the important statement "chest and abdomen clothed with dark tawny hairs," of which there is no trace in *C. atropos*.

2. Chrysops excitans.

Chrysops excitans Walker, Dipt. Saunders, p. 72.

♀. Apex of the wings hyaline; proximal half of the two basal cells infuscated; two or three basal segments of the abdomen yellowish on the sides; a distinct gray or yellowish-gray triangle on the second segment. Length, 10–12 mm.

♂. Body altogether black. Coloring of the wings darker than in ♀, with a fenestrate hyaline spot in the middle. Length, 10–11 mm.

Female. The black, shining facial callosities prolonged in front and converging above the mouth; between them, a short pointed stripe of fulvous pollen; similar stripes separate the callosities from the black, shining cheeks; frontal callosity large, black, shining, separated from the black spot on the vertex by a fulvous crossband attenuated in the middle; the orbits and the root of the antennæ show narrow margins of the same fulvous pollen. Antennæ: first joint reddish-black at tip; second joint darker, almost black, although showing traces of red, especially on the under side; third joint black. Thorax blackish, clothed with fulvous hair, especially dense on the pleuræ; on the dorsum the beginning of a broad, but faint gray stripe is visible anteriorly; it is more or less distinctly margined with lines of yellowish pollen on each side, and is divided longitudinally by a faint, black line. Abdomen black, the sides of two, sometimes three, basal segments, yellowish tawny; the posterior margins of the second, third and fourth segments show, on the black color in the middle, triangles beset with golden hair; that on the second segment is especially large and distinct; (in rubbed specimens this triangle is grayish or yellowish, the latter in such specimens where the yellow on both sides is continued along the posterior margin). The third and following abdominal segments are black, clothed with golden-yellow hair on their surface, as well as on their posterior margin. Venter yellowish-tawny at the base, black towards the tip, the black more or less encroaching upon the yellow along the central line in the shape of spots of different sizes in different specimens. Legs black, with a vestige of brownish at the basis of the tibiæ and of the four posterior tarsi. Wings with a hyaline apex; the two basal cells infuscated up to the middle; the crossband does not reach the posterior margin and does not fill out the fourth posterior cell; the inner end of the fifth posterior cell is infuscated, although less dark than the crossband; anal cell and anal angle have a slight brownish tinge; the fifth vein, up to the crossvein, is brown in older specimens. A more or less distinct whitish halo along the distal margin of the crossband, sometimes hardly apparent.

The coloring of the abdomen of the female is very variable in the extent of the yellow; in some specimens the sides of the third and even of the fourth segments are of that color; in one specimen (British Possessions, Scudder) the yellow is the prevailing color on the abdomen, reaching the fifth segment, and leaving only a square black spot in the middle of the first, fourth and fifth segments, and a bilobed spot on the second and third. The coloring of the venter shows more or less yellow, in proportion to the upper surface; in

the latter specimen, the venter is almost entirely yellow, except at the extreme tip; in very dark specimens it is almost entirely black. The pattern of the wings is remarkably uniform in all specimens.

Male. Body altogether black; abdomen, towards the tip with grayish golden hairs, which, on the second, third, and fourth segments, form faint triangles; (in rubbed off specimens a very faint gray triangle is visible on the second segment). Venter black, sometimes brownish on the sides of the posterior margins of the segments, clothed with golden hairs, especially on the margins. The thorax is clothed with black hairs; in some specimens, however, rather numerous yellowish-gray hairs are mixed with them, in which case the thorax somewhat resembles that of the female; a trace of gray pollen is visible anteriorly. The pattern of the wings is like that of the female, only the brown of the two basal cells is more intense and reaches beyond the middle of the cells, reaching the brown in the proximal end of the fifth posterior cell, thus leaving a well-marked hyaline fenestrate spot in the shape of a parallelogram in the middle of the wing. The brownish tinge in the anal cell and in the anal angle is also more saturate than in the female. A slight blackish shadow (indistinct in some specimens), is visible in the hyaline portion of the marginal cell, near the costa (a mere vestige of it is often perceptible in female specimens).

Hab. A common and wide-spread species. Catskill, N. Y., in July; Waterville, N. H., July (Scudder); different parts of British America (the same); Lake Superior (A. Agassiz); Yukon River and MacKenzie River (Kennicott); Anticosti (Verrill), etc. Twenty-five female and five male specimens.

Observation. The description was principally drawn from eight well preserved and fresh specimens, male and female, which I caught in the summer of 1874 near the Mountain House, Catskill, N. Y. The specimens from Anticosti are very dark, and the facial pollen is grayish, rather than fulvous. I have but little doubt concerning the identity of the above described species with Mr. Walker's *C. excitans*. Some error must have been committed by him in the description of the antennæ, which is not clear. He describes only the female.

3. Chrysops mitis n. sp.

?*Chrysops provocans* Walker, Dipt. Saund., p. 73.

♀. Apex of the wings hyaline; proximal half of the two basal cells infuscated; anal cell and anal angle more or less tinged with brownish; two grayish, interrupted lines on the thorax; abdomen altogether black, with faint triangles of grayish hair.

Length, 11–12 mm.

Not unlike the preceding species, from which the female is easily distinguished by an altogether black abdomen, with a grayish and not golden pubescence.

Female. Head as in *C. excitans*, only the pollen on face and front is yellowish-gray, instead of fulvous; (in one of my specimens, however, it is fulvous). Antennæ black, first joint reddish, black at tip; second, blackish-red on the underside. Thoracic dorsum with two gray longitudinal lines, reaching to about the middle; interval between them brownish, grayish-pollinose anteriorly, where the beginning of a blackish line is visible; pleuræ with dense yellowish-gray hairs in the upper part; some black hairs between the root of the wings and the humeri. Abdomen black, with a thinly scattered grayish pubescence, more

dense on the sides and towards the apex; on the second and third segments this pubescence forms faint triangles. Legs black, root of the four posterior tarsi brownish. Pattern of the wings as in *C. excitans*, except that the brown coloring is somewhat less dark, and that the brown in the two basal cells reaches a little farther, so that the hyaline space between this brown and that of the crossband is a little narrower, especially in the second cell. An indistinct whitish halo along the distal margin of the crossband.

Hab. British Possessions in N. America from Canada (W. Couper), to MacKenzie and Yukon Rivers (R. Kennicott); Lake Superior. Nine females.

This species is not unlike *C. excitans*, but is easily distinguished by the altogether black coloring of the abdomen, the two gray stripes on the thorax, which are much more distinct than the corresponding yellowish lines in that species, the above indicated slight difference in the coloring of the wings, etc. The brown of the picture, in most specimens, seems to be a little less dark than in *C. excitans*. The resemblance of *C. mitis* to *C. celer* will be discussed under the head of the latter species.

The identity of Mr. Walker's *C. provocans* with the present species seems probable. The statement that the facial callosities are larger than those of *C. excitans* agrees with this species better than with *C. celer*; the "tuft of pale yellow hairs . . . at the base of the wings", describes the pubescence of *C. mitis*, rather than the ferruginous pubescence of *C. celer*; but the statement that the crossband approaches nearer the hind border than that of *C. excitans*, renders the identification doubtful.

Macquart's description of *C. ater* agrees with the present species, except in size. As he compares *C. ater* to *C. niger* and at the same time makes it *half a line smaller*, the identification with *C. mitis* becomes impossible.

4. Chrysops fugax n. sp.

? *Chrysops carbonarius* Walker, List, etc., I, p. 203 (*ex parte*).

? *Chrysops ater* Macquart, Dipt. Exot. 4e Suppl., p. 40.

♀. Like *C. mitis*, but smaller; whitish lines of the thorax imperceptible; gray triangles on abdomen almost imperceptible; a small hyaline spot at the proximal end of the fifth posterior cell.

Length, 8–9 mm.

I should hesitate to separate this from the preceding species, if it were not for the constancy of the characters just given. I have fourteen female specimens before me; from Norway, Me. (S. I. Smith), Gorham, N. H. (Austin), Canada (W. Couper), divide between Idaho and Montana (C. Thomas), Yukon River (Kennicott). All agree in having the fifth posterior cell hyaline at the proximal end, and not filled out with a brownish tinge; this hyaline spot coalesces with the hyaline space in the second basal cell. All such specimens are considerably smaller than the average-sized specimens of *C. mitis* and the best preserved among them show but a vestige of the whitish lines on the anterior part of the thorax, which are comparatively distinct in the other species. The dorsal triangles on the abdomen also, are hardly perceptible or not visible at all. In size and general appearance this species is not unlike *C. niger*, and I suspect that Mr. Walker's *C. carbonarius* is a mixture of the present species with *C. niger* Macq. His Var. β would, in this case, especially refer to *C. niger*. All the statements, which do not agree with *C. fugax* (as that the crossband "ex-

tends to the hind border," the description of the four hind tarsi, etc.) apply much better to *C. niger*. It must be borne in mind at the same time that what Mr. Walker had as *C. niger* is not Macquart's species at all, but my *C. sordidus*.

Macquart's *C. ater*, if we follow the letter of his description, may be the present species; nevertheless his statements are too vague for a positive identification.

5. Chrysops celer n. sp.

♀. Apex of the wings hyaline; proximal half of the two basal cells infuscated; body black; a conspicuous tuft of yellowish-ferruginous hairs on each side of the thorax.

Length, 11–12 mm.

Female. Facial and frontal callosities as in *C. excitans*, only somewhat smaller; the line of fulvous pollen separating the facial callosities is broad and short; on the front the pollen is more grayish. Antennæ ferruginous, except the latter portion of the third joint, which is black. Thorax with a very faint grayish median stripe enclosed between two gray lines, interrupted before the middle of the dorsum; the latter is clothed with short, grayish-white hairs. On each side of the thorax, between the root of the wings and the head, there is a conspicuous tuft of yellowish-ferruginous hairs, characteristic of the species. Abdomen uniformly black, clothed with a short, appressed grayish-white pubescence, which in well preserved specimens forms faint triangles in the middle of the second and third segments. Legs black, the four posterior tarsi with the first joint paler, except at tip; the following joints sometimes show a trace of the same pale color at the root. Wings: apex hyaline; the crossband does not quite reach the posterior margin, but extends, although in a paler shade, into the fifth posterior cell; two basal cells filled out with brown up to the middle, or a little beyond; anal angle and a portion of the anal cell tinged with gray; the whitish halo along the distal margin of the crossband is distinct.

Hab. Not rare in the Middle States; occurs also in Massachusetts. Eight females.

In many respects *C. celer* is very like *C. mitis*, but is easily distinguished by the tufts of ferruginous hairs on the thorax. The facial callosities of *C. mitis* are larger, the picture of the wings usually not quite as dark, etc.

6. Chrysops sordidus n. sp.

Chrysops niger Walker (nec Macquart), List, etc., I, p. 202.

♀. Apex of the wings subhyaline; second basal cell nearly hyaline, being infuscated at the proximal end only; an incipient apical spot in the shape of a faint cloud along the costa; abdominal segments on the posterior margins with narrow gray borders, and with small gray triangles in the middle; first and second segments with small yellow spots on the sides.

Length, 9–10 mm.

Female. Frontal and facial callosities, and the yellowish-gray or grayish-yellow pollen around them the same as usual in this group. Antennæ black, first joint reddish, except the tip (in some specimens the red is hardly perceptible). Thorax with a broad, but faint, grayish stripe, reaching beyond the middle and divided longitudinally by a faint blackish line; the lines which enclose it on the sides are blackish (and not gray or yellowish, as in *C. mitis, excitans*, etc.). Thoracic dorsum clothed with yellowish-gray hairs; tufts of longer

and denser yellow, sometimes almost fulvous hairs near the root of the wings and on the upper part of the pleuræ. Abdomen black; first and second segments more or less yellowish on the sides; all the segments, except the first, with a narrow gray border posteriorly, which expands into a distinct triangle on the first two segments, and a less distinct one on the third. In well preserved specimens these gray margins and triangles are clothed with a golden-yellow pubescence. On the venter the segments are covered with gray pollen posteriorly, and clothed with yellowish hairs. Legs black, the brownish color at the root of the four posterior tarsi hardly perceptible. Wings: general coloring of the hyaline portion dingy grayish; the brown portions but moderately dark; costal cells brown, first basal cell infuscated on its proximal half; second basal cell almost hyaline, except its extreme proximal end; fifth longitudinal vein more or less clouded with brownish, which, in some specimens, forms a distinct border inside of the second basal cell; the crossband does not reach the posterior margin, and fills obliquely the proximal half of the fourth posterior cell; a pale brown cloud fills the proximal end of the fifth posterior cell. The space along the costa between the crossband and the tip of the wing is faintly tinged with brown. The halo along the distal margin of the crossband is indistinct, although the apical portion of the wing is rather grayish.

Hab. White Mountains, N. H. Nine female specimens. The yellow color on the sides of the abdomen has more or less extent in different specimens; sometimes it is confined to the anterior corners of the second segment and is hardly perceptible on the first; such specimens have the first antennal joints almost black. On the average, the yellow on the abdomen has much less extent than in *C. excitans*, and only extreme cases in both species show any approach to each other. *C. sordidus* is easily distinguished from all the preceding species by the gray posterior margins of the abdominal segments. Although the hairs upon them can be rubbed off, the gray margins and triangles remain, which is not the case in the other species of this group. (Only the triangle on the second segment in *C. excitans*, and perhaps in *C. mitis*, shows the same permanence.)

Mr. Walker's description of *Chrysops niger* is based on specimens of the present species, as the description of the abdomen undoubtedly proves.

7. Chrysops niger.

Chrysops niger Macquart, Dipt. Exot., I, 1, 161, 10.

? *Chrysops carbonarius* Walker, List, etc., I, p. 203, Variet. β.

♀. Apex of the wings hyaline; second basal cell altogether hyaline; face ferruginous in the middle. Length, 6¼–8 mm.

Female. The black, shining facial callosities are separated by a large, shining, yellowish-ferruginous spot extending from the antennæ down to the mouth; the black, shining cheeks are separated from the callosities above them by the usual stripe of fulvous pollen; the pollen on the front is grayish-yellow. Antennæ: first joint reddish, often blackish at tip; second, blackish, mixed with reddish; third, black, reddish at base. Thorax with a broad greenish-gray pollinose stripe in the middle, divided longitudinally by a blackish line; its sides are more distinctly gray, assuming the appearance of two gray lines; on each side of

the dorsum, a grayish stripe, followed by a black one, between the root of the wings and the humeri; on the pleuræ a gray stripe, beset with long, yellowish hairs, is followed by a black one, and then by a second gray stripe extending posteriorly over the base of the abdomen. Abdomen black, with short, appressed grayish hairs. Legs black, first two joints of the four posterior tarsi livid, black at tip; sometimes the middle and hind tibiæ have a reddish tinge at the root. Wings: second basal cell and fifth posterior cell hyaline, so that the crossband is bounded posteriorly by the intercalary vein; there is a hyaline spot just before the distal end of the first basal cell (a vestige of the larger spot existing here in the other species of the group); the crossband almost touches the posterior margin, the extent of the intervening space not quite constant in different specimens; apex hyaline.

Hab. Middle and Northern States and British Possessions; not rare. In some specimens there is a paler streak in the fourth posterior cell, by the side of the intercalary vein; in others, a faint brownish tinge appears in the fifth posterior cell; or also on the margin at the tip of the fifth and sixth veins; sometimes there is a pale brown, very small cloud at the base of the fork of the third longitudinal vein.

I have a specimen from Illinois in which the first basal cell is almost entirely hyaline, showing only a trace of a brownish tinge on its proximal half. The specimen is a fully matured one, and otherwise normally colored. Until further evidence, I incline to think that it represents only an accidental aberration.

C. niger in several respects forms the passage to the next group. Its ferruginous face and the distinct longitudinal black stripes on the pleuræ foreshadow the coloring of that group.

The mention of "face fauve" by Macquart, and the description of the wings, seems to render the identification of this species certain, although the measurement given, five lines (about 11 mm.), is too large for this species.

Mr. Walker's description of *C. niger* (List. etc., I, p. 202) is principally based on specimens of *C. sordidus*. His *C. carbonarius*, var. β (evidently a different species from his type) seems to belong to the present species.

B. The apical portion of the wing, beyond the crossband, is more or less tinged with brown, either in the shape of a distinct brown border along the costa, or of a separate apical spot.

8. Chrysops æstuans.

Chrysops æstuans v. der Wulp, Tijdschr. v. Ent., 2 Ser. II, p. 135; Tab. III, f. 8, 9.

? *Chrysops mœrens* Walker, List, etc., I, p. 201.

♀. Apical spot confined to a faint and narrow infuscation along the costa; both basal cells hyaline; halo along the crossband very distinct; the ends of the Λ-shaped black spot on the second abdominal segment expand into small black triangles on the posterior margin.

Length, 10 mm.

Female. Face, including the facial callosities, and cheeks yellowish-ferruginous, shining; facial orbits and the usual stripe between face and cheeks, powdered with yellowish-gray pollen; front covered with the same pollen, except the black frontal callosity and a blackish space on the vertex. Two basal joints of the antennæ ferruginous, clothed with black hair; third joint blackish, ferruginous at base. Palpi variable in color, reddish or brownish, red-

dish at base. Thorax black; a broad, glaucous intermediate stripe is divided in two by a black longitudinal line; on each side a glaucous-grayish stripe runs above the root of the wings, from the scutellum to the humerus; a blackish stripe separates it from the glaucous-grayish pleuræ; the latter glaucous-grayish, with a black stripe. Scutellum blackish. Abdomen black; first two segments pale grayish-yellow (livid) on the sides, black in the middle; the black on the second segment has somewhat the shape of a Λ, the middle triangle of this figure being of the same color as the sides of the abdomen; both ends of this figure expand laterally in the shape of small black triangles, resting upon the hind margin of the segment; the following segments are black, with a narrow gray posterior border, expanding into a triangle, with two adjacent gray marks; these triangles and marks are especially visible on segments 3-5. Wings: root, costal cells and crossband brown; beyond the crossband a narrow pale brownish cloud along the costa nearly reaches the tip of the wing; the crossband does not reach the posterior margin, the distal end of the fourth posterior cell being colorless, the last section of the fifth vein enveloped in a brownish cloud, connected with the crossband across the proximal end of the fifth posterior cell; the apex of the wing is grayish, with a very distinct whitish halo between it and the crossband; similarly, a brownish shadow in the anal angle of the wing renders more apparent the whitish-hyaline tinge of the two basal and of the proximal end of the anal cell. Legs variable in coloring; either red, tips of front and hind tibiæ, front tarsi, and last four joints of the four posterior tarsi, blackish; or black, bases of middle tibiæ and of the four posterior tarsi, reddish; with all the intermediate stages.

Hab. Red River of the North (Kennicott); Illinois (LeBaron); Wisconsin (v. d. Wulp); Dacota (Dr. Coues).

The extent of the yellow color on the abdomen is variable in this species. I have a specimen before me (Red River of the North) where the small black triangles on the second segment have their apex prolonged so as to meet the black on the corresponding side of the first segment. In another specimen (Illinois) with very dark legs, the yellow on the sides of the abdomen is replaced by a glaucous-gray, the black design of the first two segments being the normal one.

Mr. van der Wulp's description and figure are excellent, and refer to the variety with the darker feet. Mr. Walker's description is very incomplete, and is rendered still more doubtful by the locality (Nova Scotia); all the specimens of *C. æstuans* hitherto received come from the Northwest.

9. Chrysops callidus n. sp.

♀. Apical spot in the shape of a narrow linear brown border along the costa; both basal cells hyaline; discal cell filled out with brown; no small black triangle on each side of the Λ-shaped black spot on the second abdominal segment.

♂. Wings as in the ♀, but both basal cells infuscated, with a common hyaline spot at the distal end. Length, 8–9 mm.

Female. Head, antennæ and picture of the thorax as in *C. æstuans*; the lateral stripes on the thorax and the pleuræ are more yellowish than glaucous; palpi more reddish. Abdomen black; first two segments pale yellow on the sides, black in the middle; the black

on the second segment has the shape of a Λ, the triangle encompassed by this figure being of the same color as the sides of the abdomen; the ends of this figure are sometimes (not always) prolonged laterally, along the hind margin, without expanding into small black triangles; segments 3 and 4 are black or brown, with yellow hind margins, expanding into triangles in the middle; on the black, a yellow spot is often perceptible on each side; in some specimens the whole of the segments 3 and 4 are yellow, except a double obtriangular spot in the middle, and a small dot, each side, near the anterior margin; segments 5-7 black or brown, with yellow hind margins. Venter yellow at base, blackish at tip; segments 3 and 4 often with blackish spots in the middle. Legs variable in coloring; either the prevailing color is yellowish-red, with the tips of front femora, front tibiæ, the whole hind femora and all the tarsi, except the base, black; or the prevailing color is black, with the middle tibiæ, the bases of front and hind tibiæ, and base of the tarsi, reddish. The description of the wings of *C. æstuans* applies to this species, with the following differences; the narrow brown border along the costa, between the crossband and the apex, is of the same shade of brown as the crossband and of the same breadth as the costal border between the crossband and the root of the wing; it reaches a little beyond the anterior branch of the fork of the third vein; the gray shade of the apical portion of the wing is much fainter, and hence the white halo along the crossband less distinct; the fourth posterior cell is almost filled out with brown, so that the end of the crossband is much nearer the posterior margin of the wing.

Hab. New Jersey; Delaware; Connecticut; Detroit, Mich. (H. G. Hubbard); Illinois (LeBaron). Eleven female specimens. The smaller size, the dark, well defined brown border between crossband and apex, the absence of the black triangles encroaching upon the yellow of the second segment, the yellow and not gray, hind border of the abdominal segments, easily distinguish the female of this species from the preceding.

Male. Two male specimens (Pennsylvania and New York) which I possess, belong, I have no doubt, to this species. The picture of the wings, especially the brown border between the crossband and the apex, is like that of *C. callidus*, only the two basal cells are filled out with brown up to their distal third, which is hyaline. The brown of the basal cells coalesces with the brown cloud, enveloping the last section of the fifth longitudinal vein. The facial callosities are brownish, the middle of the face reddish. Antennæ black. The coloring of the thorax is darker, the stripes less conspicuous. The sides of the abdomen are reddish-yellow, which color, in one of the specimens, extends to the third segment; the yellow triangles on the hind margins of the segments seem a little smaller, but the characteristic yellow hind margins are very distinct, and somewhat broader than in the female. The yellow dots on the back of the third segment are very plain in one of the specimens; in the other, yellow marks are visible on the fourth segment.

10. Chrysops delicatulus n. sp.

♀. Apical spot in the shape of a narrow linear brown border along the costa, attenuated at the distal end of the stigma; both basal cells hyaline; discal cell almost hyaline; the Λ-shaped black spot on the second segment broad in its outline; facial callosities and cheeks black.

Length, 6.5–7.5 mm.

Female. Facial callosities and cheeks black, the upper part of the former somewhat brownish; middle portion of the face dark ferruginous; the usual pollen on the face and around the black frontal callosity, gray. Antennæ black, first joint pale reddish. Thorax with a broad glaucous middle stripe, divided longitudinally by a black line: grayish glaucous lateral stripes; pleuræ likewise grayish-glaucous, with the usual blackish stripes. The first two abdominal segments are pale yellow on the sides; the black on the first segment occupies the whole base of the segment (and not the middle only, as in *C. callidus*); the Λ-shaped black spot on the second segment is rather broad in its outline, and its ends, prolonged along the hind margin, are as broad as the main body of the figure (in *C. callidus* they are usually narrower): they do not reach the lateral margin; the yellow triangle enclosed in the Λ-shaped spot is somewhat smaller than in *C. callidus*. The other abdominal segments are black, with narrow yellowish-gray margins, two or three of which expand into triangles. Legs black; base of front tibiæ, the major part of the middle tibiæ and roots of the four posterior tarsi reddish-brown. Wings: costal cell, crossband and a narrow costal border beyond, brown; the crossband is rather narrow and attenuated posteriorly; its distal margin is very straight; its proximal side does not fill out the proximal half of the discal cell, which is hyaline; a part of the fourth posterior cell is also hyaline; a brown cloud on the last section of the fifth vein; otherwise the fifth posterior cell likewise hyaline; the brown border along the costa, between the crossband and the apex, is but little broader than the infuscated costal cell between the crossband and the root of the wing, and is narrowed at its origin from the crossband, where a subhyaline indentation almost severs it from the crossband; the fifth longitudinal vein before the crossvein is yellow.

Hab. North Conway, N. H., where I caught two females of this handsome species in the middle of August, 1874.

The smaller size, the coloring of the face and the peculiar picture of the wings easily distinguish this species from the two preceding ones.

11. Chrysops pudicus n. sp.

♀. Apical spot connected with the crossband, the hyaline triangle between them not crossing the second longitudinal vein; the apical spot invades but a small portion of the second submarginal cell; both basal cells, (except at their extreme proximal end), hyaline; frontal callosity reddish; first and second abdominal segments yellow on the sides; the black on the second segment Λ-shaped.

Length, 8 mm.

Female. Face, including the callosities, yellowish-ferruginous; palpi reddish-yellow; antennæ: first two joints and base of third reddish, the remainder black; front with a grayish pollen; frontal callosity reddish, usually with a black margin above. Thorax with the usual stripes, glaucous above, grayish-yellow on the pleuræ. Abdomen: two first segments yellow; the first with a black spot in the middle, the second with a stout Λ-shaped black spot, not confluent with the first; in some specimens the ends of the Λ-shaped spot reach the hind margin of the second segment and expand beside it, in others they are separated from the margin by a yellow border. The third and fourth segments are yellow, with a large transverse black spot in the middle, encroached upon by the triangular enlargement of the yellow hind margin; the relative extent of the black and the yellow

are somewhat variable. The following segments are black, with yellow sides and posterior margins. Venter yellowish at the base, black at the end, the relative extent of both colors being variable. Legs: prevailing color reddish, with more or less brown at the base of the hind femora, the tip of the hind tibiæ and the ends of the four posterior tarsi, the latter half of the front tibiæ and the front tarsi brown. Wings: costal cell infuscated, the brown also occupying the proximal third of the first basal cell and encroaching very slightly upon the second; crossband limited posteriorly by the intercalary vein, but filling out the fourth posterior cell and thus reaching the hind margin; last section of the fifth vein enveloped in a brownish cloud; the interval between this cloud and the crossband is hyaline. The hyaline triangle, separating the crossband from the apical spot does not reach anteriorly beyond the second longitudinal vein; thus the apical spot coalesces with the crossband within the marginal cell; posteriorly, the apical spot reaches a little beyond the apex of the wing.

Hab. Massachusetts (Beverly, Cambridge, etc.,) collected by Messrs. Burgess and Sanborn; three females. A fourth female specimen, belonging to the Entomol. Soc., Philad., therefore probably from the Middle States, agrees in all particulars with the others.

Observation. Two female specimens (Illinois and Red River of the North, by R. Kennicott), which I have before me, differ in some particulars from the typical specimens of *C. pudicus*. The crossband does not reach the hind margin, a considerable portion of the fourth posterior cell not being filled out with brown; the apical spot is somewhat narrower, the cloud on the last section of the fifth vein communicates with the crossband across the base of the fifth posterior cell; the apex of the Λ-shaped spot on the second abdominal segment coalesces with the black on the first segment, etc. This is probably a distinct species.

12. Chrysops montanus n. sp.

♀. Apical spot connected with the crossband, hyaline triangle between them not crossing the second longitudinal vein; both basal cells nearly hyaline, and only a little infuscated at the proximal end; frontal callosity black; facial tubercles yellowish-ferruginous; third and fourth abdominal segments with four black longitudinal spots, alternating with yellow ones.

Length, 8 mm.

Female. Face (including the facial callosities), yellowish-ferruginous; palpi reddish-yellow; antennæ: first two joints reddish, the second mixed with black; both beset with black hairs; third joint black, somewhat reddish at the base. Frontal callosity black; front with yellowish-gray pollen. Thorax with the usual stripes, the intermediate one with a slightly more yellowish tinge than in *C. rubens*, the lateral ones yellow. Abdomen: first two segments yellow; the first with a blackish spot in the middle, under the scutellum; the second with a Λ-shaped black spot, both branches of which are less divaricate than in *C. rubens*; in my three specimens this spot does not coalesce anteriorly with the spot of the first segment; the third segment shows four longitudinal black spots on yellow ground; the intermediate pair, which is the broader, is connected anteriorly, with the branches of the Λ-shaped spot, and posteriorly, with similar spots on the fourth segment; the lateral spots of the third segment are continued only posteriorly by similar spots in the next seg-

ment; four black longitudinal stripes are thus formed, interrupted only by the very narrow posterior margins; these stripes are also continued on the fifth segment, but the black here prevails to such a degree that only faint traces of yellow are left between the black spots; the fifth segment thus appears nearly black or brown, with a yellow, more or less jagged, posterior margin; the same may be said of the sixth segment. Venter yellow; segments 3 and 4 with black lines on the sides; the last segments blackish, with yellow margins. Legs reddish; the front pair has the second half of tibiæ, and the whole tarsi, the middle pair has the coxæ, root of femora, knees and tips of tarsi, the hind pair the femora, except a pale ring before the knees, the latter part of the tibiæ and the tips of tarsi, black; hind tibiæ beset with black hairs. Wings: both basal cells hyaline, the brown color not occupying more than one-third of the first basal cell and hardly encroaching upon the second; crossband filling out the fourth posterior cell: the brown cloud, enveloping the last section of the fifth vein, communicates more or less with the crossband across the fifth posterior cell; the hyaline triangle between the crossband and the apical spot does not cross over the second longitudinal vein, although opposite its apex, at the end of the stigma, a small subhyaline dot is visible; the apical spot is like that of the preceding species, only it occupies a larger portion of the second submarginal cell.

Hab. Catskill Mountain House, N. Y., July, 1874. Two females; a third one, from Ogle Co., Illin., has the yellow on the abdomen more extensive in comparison to the black; on the legs, the red prevails to a greater extent, the hind femora being of that color. There is hardly any difference between this species and *C. pudicus* in the coloring of the wings, except that the apical spot is somewhat larger.

13. Chrysops indus n. sp.

♀. The apical spot fills out the marginal and first submarginal cells and invades a portion of the second submarginal; the crossband does not quite reach the posterior margin, but expands somewhat towards the anal angle; first basal cell almost filled out with brown, the second infuscated at the proximal end only. Face and facial callosities ferruginous; abdomen with yellow sides and yellow triangles in the middle.

Length, 8–10 mm.

Female. Face, including the cheeks, altogether ferruginous; only the pits existing under the facial callosities are brown; the stripes of pollen, separating the cheeks, and clothing the facial orbit, are fulvous; frontal callosity and space around the ocelli, black; pollen on the front, grayish. Antennæ: first joint red, the second and base of the third more or less tinged with reddish, the remainder black. Thorax black, with the usual stripes: a grayish median stripe, margined with more distinct gray lines on each side and with a blackish longitudinal line in the middle; a pair of greenish-yellow lateral stripes, passing above the root of the wings; a broad brown stripe between the root of the wings and the humerus; pleuræ yellowish-gray, with yellowish hairs and a brown stripe in the middle. Abdomen yellow; first and second segments each with a square black spot in the middle, coalescent along the hind margin of the first segment; the spot on the second segment bears, on the hind margin, a large yellow triangle (a faint trace of a similar, but much smaller, triangle, is perceptible on the black spot of the first segment); the third and fourth segments are black, each with a narrow posterior margin, broad lateral margins, and

a triangle in the middle, yellow; an indistinct yellowish streak runs, on each side, from the anterior margin of the segment, inside of the black, and does not reach the middle of the segment; the fifth and the following segments are black, with yellow hind margins; on the fifth the vestige of a triangle. Venter yellow; blackish longitudinal lines on each side of segments 2–4; the following segments black, with yellow margins. Legs ferruginous; latter half of front tibiæ and the front tarsi, black; ends of the four posterior tarsi, tips of hind femora and tibiæ, blackish. Wings: costal and first basal cells, the latter except a small hyaline square at its distal end, dark brown; the proximal end of the second basal cell contains a brown streak, not quite reaching the middle of the cell; the dark brown crossband does not touch the hind margin, a small space at the end of the fourth posterior cell being hyaline; the fifth posterior cell (except both its ends) and the end of the anal cell, are also infuscated; a faint brown tinge spreads across the anal angle; the apical spot is coalescent with the crossband, marginal and first submarginal cells being filled out with brown; the second submarginal cell is encroached upon by a brown cloud on its anterior half only; a trace of a whitish halo on the distal margin of the crossband.

Hab. Two female specimens, the one from Cayuga Lake, N. Y. (J. H. Comstock), the other from Montreal (Wm. Cooper), agree in all the above described characters.

This species is very like *C. pudicus, montanus, hilaris*, etc., in its general appearance and somewhat in the coloring of its abdomen; but it is easily distinguished by the coloring of its wings, as in all the above named species the first basal cell is nearly hyaline and the first submarginal cell contains a hyaline space, separating the brown crossband from the apical spot. In *C. striatus* the hyaline spot at the end of the first basal cell is much smaller, the crossband stops short at the intercalary vein, the picture of the abdomen is altogether different, etc.

14. Chrysops frigidus n. sp.

♀. The apical spot fills out the marginal and first submarginal cells, and invades a portion of the second submarginal; the crossband does not reach the posterior margin, but expands toward the anal angle; basal cells infuscated on their proximal half; face shining black, with the usual stripes of yellow pollen; abdomen black, sides of the two basal segments yellow.

Length, 7–8 mm.

♂. The brown color in the basal cells occupies more space; abdomen reddish-yellow, each segment with a black spot in the middle; three last segments black.

Female. Facial callosities black, shining, prolonged anteriorly and meeting above the mouth; between them a stripe of yellowish-gray pollen; cheeks black, shining, separated from the facial callosities by broader stripes of the same pollen. Front clothed with grayish pollen; frontal callosity and space around the ocelli, black. Antennæ black, the first two joints more or less tinged with reddish; first joint comparatively stout. Thorax blackish, clothed with yellowish hairs, especially on the sides of the dorsum and on the pleuræ; a broad median greenish-gray stripe, brownish in the middle, lateral greenish-gray stripes between the humeri and the scutellum; a brown stripe between the humeri and the roots of the wings; pleuræ yellowish-gray, with yellow hairs and a blackish stripe in the middle. Abdomen black, sides of the two first segments reddish, leaving on the second segment a

more or less trapezoidal black spot in the middle: on the hind margin of the second segment, in the middle of this black spot, a gray triangle is visible: the following segments are black, with similar gray triangles in the middle (often very faint); hind margins of the segments grayish, becoming yellowish on the sides. In well preserved specimens the gray triangles and the hind margins are beset with a golden-yellow pubescence. In some specimens the reddish color on the first two segments occupies much more space, the extent of the black color being smaller in consequence; in such cases the third and fourth segments also show some reddish on the sides. Venter yellowish at the base, with more or less black in the middle; the latter half black; hind margins of the segments paler. Legs very variable in coloring, the black color prevailing in some specimens, the red in others. Wings: root, costal cells, proximal half of both basal cells, brown; the crossband does not reach the posterior margin, the distal end of the fourth posterior cell being more or less hyaline; the crossband is not limited posteriorly by the intercalary vein, but fills out more or less the proximal end of the fifth posterior and the distal end of the anal cell, where it is fainter: it even extends, but as a very faint gray tinge, into the anal angle; the apical spot is coalescent with the crossband in the marginal and first submarginal cells, which are completely filled out with brown; the second submarginal cell is brownish on its anterior half only.

Male. The thorax is more yellowish hairy, and its stripes less apparent; the abdomen is reddish-yellow; segments 1–4 with black spots in the middle, which are broader in front than behind; they do not reach the hind margins, except the spot on the first segment, which coalesces with that on the second; segments 5–7 black, with the hind margins yellow. Venter yellow; first two segments with black spots in the middle; segments 3 and 4 with a transverse blackish crossband, abbreviated on both sides; segments 5–7 black, with yellow hind margins. Wings as in the female, only the hyaline space at the distal end of both basal cells is smaller, and the prolongation of the crossband in the fifth posterior and anal cells darker.

I have before me two male specimens from Massachusetts, which I can only refer to this species, although I have not a single female from this state.

Hab. Great Slave Lake and Northwestern Regions of the British Possessions (R. Kennicott); Saskatchewan (Scudder); Quebeck (Bélanger); Sharon Springs, New York. Five females. Two hypothetical males from Massachusetts.

Among all the *Chrysops* with an apical spot on the wings, this species is the only one which is not marked with ferruginous in the middle of the face: the coloring of the face here is exactly similar to that of the species of the group A; in its general appearance, it reminds one of the species of that group. This character renders its recognition very easy.

15. Chrysops flavidus.

Chrysops flavidus Wiedemann, Dipt. Exot., I, 105, 5. Auss. Zweifl., I, p. 199, 7.

? *Chrysops canifrons* Walker, List, etc., I, p. 197.

♀. The hyaline triangle separating the crossband from the apical spot, almost reaches the second longi-

tudinal vein; basal cells infuscated at the proximal ends only; body altogether brownish-yellow, abdomen brownish above, with yellowish hind margins and triangles; thorax with three pale brown dorsal stripes.

Length, 9–10 mm.

♂. In all respects, except the sexual characters, similar to the female.

Length, 8 mm.

Female. Altogether brownish-yellow; face yellowish-ferruginous, including the facial callosities and cheeks; frontal callosity yellowish-red; pollen round the antennæ and on the facial orbits yellowish-white; on the front more yellowish. Antennæ: first two joints yellowish, beset with black hair; third joint comparatively short, reddish, its latter half dark brown. On the brownish-yellow, in some specimens grayish ground-color of the thorax, there are three brown dorsal stripes, the intermediate one narrower, linear; other brown stripes between the roots of the wings and the humeri and in the middle of the pleuræ; pectus brown. Scutellum yellowish-brown, often with a grayish tinge at the basis or on the sides. Abdomen pale brownish; first segment and base of the second yellowish, leaving a broad, subtriangular brownish spot, which occupies the whole posterior half of the second segment; a yellowish triangle in the middle of the hind margin; the following segments have more or less broad, yellow, hind margins expanding into pale yellow triangles in the middle; in some specimens, where the brown is more saturate, the yellow hind margin emits on each side of the triangle an oblique yellow streak, traversing the brown; the intensity and distinctness of the coloring of the abdomen is very variable. Feet reddish-yellow, end of front tibiæ, front tarsi and the ends of all the other tarsi, brownish. Halteres brownish-yellow. The picture of the wings varies from pale brown to brown; the costal cells and the stigma are yellowish-brown; the two basal cells are infuscated on the proximal half; the first more than the second; the crossband touches the hind margin and fills out the fourth posterior cell; the last section of the fifth vein is enveloped in a brown cloud, which partly fills out the distal end of the anal cell, and also communicates with the crossband across the proximal half of the fifth posterior cell; the distal half of the anal angle has a grayish tinge; its proximal half and those portions of the anal cell and of the basal cells, which are not infuscated, are whitish hyaline; the apical spot is coalescent with the crossband in the marginal and on the anterior portion of the first submarginal cell; it does not reach beyond the anterior half of the second submarginal cell; the triangular hyaline space between the crossband and the apical spot is more or less tinged with gray in different specimens; the more gray it is, the more the whitish halo along the margin of the crossband becomes apparent.

Male. Except in the usual sexual characters, it does not differ from the female.

Hab. Newport, R. I., in August; Maryland (Uhler); British America (Scudder). I caught the male in Central Park, N. Y., Sept. 6, 1869. Seven females and one male.

Wiedemann's synonymy seems certain; Walker's is probable, although doubtful; some omission must have occurred in his description of the frontal callosity and of the antennæ. I have mentioned above, in the introductory paragraph, that the coloring of the eyes of this species, in living specimens, differs from the type of coloring which prevails in the genus *Chrysops*. The anal cell is broadly open in most specimens; in one of mine, however, it is closed.

16. Chrysops univittatus.

Chrysops univittatus Macquart, Dipt. Exot., 5e Suppl., p. 36.

? Chrysops fascipennis Macquart, Hist. Nat. Dipt., I, p. 216.

♀. The hyaline interval between the crossband and the apical spot does not reach the second longitudinal vein; first basal cell altogether infuscated, the second almost hyaline; apical spot large, invading the first posterior cell; a broad yellow longitudinal stripe in the middle of the abdomen, enclosed between two brown stripes; tip of the scutellum more or less reddish.

Length 6–7 mm.

♂. A considerable portion of the second basal cell is infuscated.

Female. Face ferruginous, facial callosities often brownish; frontal callosity large, black. Antennæ: basal joints and base of the third joint reddish, the remainder black. Thorax with the usual stripes; the median stripe greenish-gray, divided by a brown longitudinal line; the lateral ones yellow. Scutellum blackish at base, reddish at tip, the extent of both colors being variable. Abdomen yellow; a broad yellow stripe extends from the base nearly to the tip; it is bounded on both sides by brown stripes, which usually become much broader on the third and following segments; the tip of the abdomen is altogether brown; venter yellow, with a broad brown middle stripe, attenuated anteriorly, and narrow lateral brown lines. Legs reddish; latter half of front tibiæ and the front tarsi black; tips of the other tarsi brownish. Wings: costal and first basal cells brown; crossband limited posteriorly by the intercalary vein and filling out the fourth posterior cell; apical spot large, reaching the second posterior cell and separated from the crossband by an elongated hyaline space, very irregular and jagged on its distal side, and having its apex immediately above the proximal end of the second submarginal cell; there is a distinct brown cloud at the distal end of the anal cell, on the margin of the wing; fifth posterior cell usually hyaline: second basal cell with a brown streak on its proximal half.

Hab. District Columbia, Maryland, New Jersey, Connecticut, Kentucky (F. G. Sanborn). Eleven females.

A male, apparently belonging to this species (Tarrytown, N. Y., in June), has all the characters of the female, except that the thorax is more brownish and hairy; the brown stripes on the abdomen are not expanded posteriorly; and the brown color in the second basal cell is more extensive. The identity of this species with Macquart's *C. univittatus* can hardly be called in doubt.

C. fascipennis Macq., Hist. Nat. Dipt., I, p. 216, is certainly one of the common species of the genus, but the shortness of the description renders the identification impossible. As far as it goes, the description reminds one of *C. univittatus* Macq., more than of any other species, especially if we take into account the statement about the small size of the species (3½ l.). Macquart has, more than once, described his own species a second time.

17. Chrysops mœchus n. sp.

♀. Apical spot altogether coalescent with the crossband, the hyaline triangle between them being small, included within the third and fourth posterior cells; abdomen yellow, with more or less broad brown stripes; scutellum more or less yellowish.

♂. Body altogether black, thorax with greenish-yellow lateral and pleural stripes; wings altogether

brown, except the anal angle, which is grayish, the hyaline triangle near the apex, and some hyaline spots in the fifth posterior cell.

Length, 7–8 mm.

Female. Face, including the callosities, yellowish-ferruginous; front beset with yellowish-gray pollen, frontal callosity black; antennæ: basal two joints reddish, the third black, reddish at base; palpi brownish-red. Thorax blackish, with the usual broad grayish median stripe, divided by a longitudinal black line; lateral stripes (between the scutellum and the humeri) yellow; a brown stripe separates the thoracic dorsum from the pleuræ; the latter with two yellow stripes, separated by a dark one. Scutellum reddish, with a blackish spot at the base, which, in some cases, extends as a stripe to the apex, leaving only a yellow spot on each side of the scutellum. Abdomen yellow, with four longitudinal black stripes of very variable breadth; in some specimens the intermediate pair of stripes consists of a series of disconnected blackish spots on segments 2–5, the lateral pair being obsolete; in other specimens the stripes are continous and broader, the lateral pair beginning sometimes on the second, sometimes only on the third, segment; (the picture of the abdomen is very like that of *C. vittatus*): the two or three last segments are usually blackish; venter yellow anteriorly, blackish posteriorly. Legs reddish, latter half of front tibiæ and front tarsi, black; tips of the other tarsi and, in some specimens, a considerable portion of the hind femora, black. Wings brown; second basal, anal, and fifth posterior cells, anal angle and a triangle on the hind margin, within the second and third posterior cells, hyaline; a brown cloud on the last section of the fifth vein.

Male. Face yellow, lateral callosities and cheeks black, shining; facial orbits and the stripe separating the cheeks from the callosities, are covered with a pale fulvous pollen; palpi black; antennæ black, first joint once and a half as long as the second. Thorax black, with black hairs; on each side of the dorsum, above the root of the wings, between the humeri and the scutellum, there is a distinct stripe of pollen, with an almost metallic greenish lustre, appearing yellowish in a different light; the usual median stripe on the dorsum shows a similar metallic greenish lustre, but darker and without yellow admixture; (it is almost invisible, unless the light falls obliquely from the side of the abdomen and is easily lost in worn specimens); a shade of the same pollen is visible on the scutellum; pleuræ with alternately brown and greenish-pollinose stripes. Abdomen brownish black, the lateral edge of the second, often also of the first and third segments, brownish-yellow; along the middle of the dorsum, especially on segments 3, 4, 5, a faint longitudinal stripe of grayish pollen is visible. Front legs blackish, except the base of the tibiæ which is brownish; middle pair brownish, except the proximal half of femora and tip of tarsi, which are black; hind pair brownish, femora and end of tarsi black. Wings altogether blackish, except the anal angle, which is grayish; a small hyaline triangle occupies the distal half of the second and third posterior cells; small subhyaline dots are visible on the fourth longitudinal vein, before the discal cell and at the proximal end of the fifth posterior cell; a faint subhyaline streak runs across these two dots and the fifth posterior cell to the posterior margin.

Hab. I have two females from Dist. Columbia and Georgia (J. Ridings); males from Kentucky (F. G. Sanborn), Missouri (C. V. Riley), and a third specimen without indication of locality.

Although I have not received specimens of both sexes *from the same locality*, I hardly doubt that the above described male really belongs to the female described as *C. mœchus*. The coloring of the body is very different in appearance, but the whole difference consists in the degree of melanism; while the characteristic traits in the coloration of the wings are the same in both sexes.

18. Chrysops morosus n. sp.

? Chrysops trinotatus Macquart, Dipt. Exot., 1, 1, p. 161, 9.

♀. The hyaline triangle separating the crossband from the apical spot is narrow, acutangular, almost crescent-shaped, and reaches the second longitudinal vein only; first basal cell infuscated; abdomen brown, with three somewhat faint brownish-yellow longitudinal stripes; the intermediate one very narrow, the lateral ones often abbreviated posteriorly.

Length, 7.5 mm.

♂. Like the female, except the sexual characters.

Female. Face ferruginous; its lateral callosities brownish or black; cheeks also brownish or black, separated from the face by the usual fulvous pollen; palpi more or less brownish. Antennæ more or less reddish-yellow on the first two joints, blackish brown on the third. Frontal callosity and a small area surrounding the ocelli, black. Thorax with the usual greenish-gray median stripe; lateral stripes yellowish (in some of the specimens they do not exist); pleuræ with two yellow stripes, separated by a brown one. Abdomen brown, with three brownish-yellow, often almost obsolete, longitudinal stripes; in one of my specimens the stripes reach from the base of the abdomen to the fourth segment; in other specimens, the lateral stripes, which are broader than the median one, do not reach beyond the hind margin of the second segment; sometimes the lateral stripes are barely visible as indistinct yellowish spots. Venter brown, with more or less yellow on the sides of the first two segments. Prevailing color of the legs reddish-yellow; distal half of the front tibiæ and the whole front tarsi, tips of the other tarsi, base of the femora, especially of the hind pair, and end of the hind tibiæ, black. Wings: root, costal cells and first basal cell, brown; the crossband is limited posteriorly by the intercalary vein, and completely fills out the fourth posterior cell; on the distal side the crossband is limited by a curve running from the second longitudinal vein, almost opposite the end of the stigma, to the tip of the vein separating the third and fourth posterior cells; this curve forms the proximal side of the hyaline crescent, separating the crossband from the apical spot; the distal side of the crescent, that is, the limit of the apical spot, is less definite, but may be described as running from the same place on the second vein, across the tip of the second submarginal cell toward the posterior margin. Thus the brown color fills out the marginal cell, except a small, but very constant, hyaline dot at the end of the stigma; it fills out the first submarginal cell, except a triangular hyaline space, which is the apex of the crescent; it fills out the second submarginal cell, except its proximal end (the base of the fork of the third vein); the first posterior cell, beyond the crossband, is partly filled by the very much faded end of the apical spot, partly hyaline, (in one of the specimens the brownish tinge almost reaches the crossband). Second basal and anal cells, and the anal angle, hyaline; a hardly visible shadow on the last section of the fifth longitudinal vein sometimes communicates across the fifth posterior cell with the crossband.

Hab. Maryland, July and beginning of August (P. R. Uhler and Mus. Philad. Entom. Soc.). Six females. The single male, which I have, resembles the females in all essential characters; the yellow stripes on the abdomen are very distinct. Two females and a male, also from Maryland, are smaller, abdomen altogether brown, front tibiæ, except the base, and hind legs, except base of tarsi, almost entirely brown. I am doubtful whether they belong here.

Macquart's *C. trinotatus* is very vaguely described, especially the wings, (only briefly mentioned in the diagnosis). It may or may not be *C. morosus*.

19. Chrysops vittatus.

Chrysops vittatus Wiedemann, Dipt. Exot., I, p. 106, 7; Auss. Zweifl., I, p. 200.
Chrysops arcolatus Walker, List, etc., I, p. 197.
Chrysops lineatus Jaennicke, Neue Exot. Dipt., p. 26.

♀. The hyaline triangle separating the crossband from the apical spot does not reach the second longitudinal vein; first basal cell to a considerable extent infuscated; the second at the proximal end only; frontal callosity and scutellum reddish; abdomen yellow with four longitudinal black lines.

Length, 8–10 mm.

♂. The second basal cell is, like the first, to a considerable extent infuscated.

Female. Face and facial callosities ferruginous-yellowish; *frontal callosity yellowish-red*; the pollen covering the front is yellow. Antennæ yellowish-red, third joint reddish at base, brown or black toward the tip. The usual stripes on the thorax are broad and well marked, yellow; the intervening spaces are brown; of the latter, the middle one is narrow. Scutellum reddish-yellow. Abdomen yellow, with four longitudinal brown stripes, usually reaching the fifth segment; the lateral stripes usually begin on the second segment only; the sixth segment is brown, with vestiges of yellow spots and a yellow hind margin. Venter yellow, blackish at tip and with two more or less distinct brown lateral stripes. Prevailing color of the legs yellowish-red; tarsi, except at base, brownish. Wings: costal and first basal cells brown; the latter with a small hyaline space before the distal end; second basal cell hyaline, with only a small brown streak at the proximal end; anal cell and anal angle hyaline; the crossband fills out the fourth posterior cell, except a very narrow, almost imperceptible, hyaline border on the posterior margin of the wing; the apical spot is broad and fills out the whole marginal and first submarginal cells, and the greater part of the second submarginal, except its proximal end, with a corresponding little hyaline spot in the first submarginal cell; posteriorly the crossband reaches beyond the intercalary vein in the shape of a more or less distinct brown cloud, crossing the fifth posterior cell and sometimes invading the tip of the anal cell; the proximal ends of the discal and of the fifth posterior cells are usually hyaline.

Hab. Middle and Northern States; not rare. A specimen from North Conway, N. H., is much darker in its general coloring, especially on the thorax.

The male, of which I have only a single, somewhat immature specimen, is in all respects like the female, except that the second basal cell is infuscated to a greater extent.

The red frontal callosity and scutellum render this species easily recognizable, and for this reason the synonymies are hardly doubtful. Mr. Walker seems to have described as

C. areolatus a specimen which had the centres of the cells on the disc of a faded brown, as is often the case, without constituting a specific character. In the description of the abdomen some omission has occurred, which renders it incomprehensible.

20. Chrysops striatus n. sp.

? Chrysops furcatus Walker, List, etc., I, p. 199.

Chrysops vittatus Bellardi (nec Wiedem.) Saggio, etc., I, p. 74.

♀. The hyaline triangle separating the crossband from the apical spot does not reach the second longitudinal vein; first basal cell to a considerable extent infuscated, *the second altogether hyaline; frontal tubercle black, scutellum blackish at base, reddish at tip;* abdomen yellow, with four longitudinal black stripes.

Length, 7–9 mm.

Female. Very like that of *C. vittatus* in its general appearance and in the coloring of its wings. It differs however in the following points: the face is ferruginous, but the facial callosities are usually brownish; the frontal callosity is black and the pollen on the front greenish-gray; the coloring of the thorax is less yellow, the median stripe being greenish-gray, with a brown line in the middle; the scutellum is more or less blackish at the base, the posterior half only being reddish; the longitudinal tripes on the abdomen are darker and better marked, especially on the first two segment, where, in *C. vittatus*, they are very often somewhat faded; the fifth posterior cell is usually hyaline, and not invaded by a brown cloud, issuing from the crossband; the latter is limited posteriorly by the intercalary vein; the apical spot is smaller, occupying only the anterior portion of the second submarginal cell; the brown at the base of the second basal cell is confined to a small spot. Venter yellow, with a broad median brown stripe, attenuated anteriorly, and two narrow lateral stripes.

Hab. District of Columbia; Illinois. Six females.

I have two doubtful specimens from Illinois (Le Baron), with the thorax and wings of *C. striatus*, but with reddish facial and frontal tubercles.

Mr. Walker's description of *C. furcatus* seems to fit the present species better than any other; nevertheless, important discrepancies in the description prevent me from admitting the synonymy. Bellardi's *C. vittatus* is very likely this species, and certainly not *C. vittatus* Wied. (compare the color of scutellum and of the frontal tubercle).

21. Chrysops hilaris n. sp.

♀. Apical spot separated from the crossband by the tip of the hyaline triangle, which reaches the costa; both basal cells hyaline; the crossband does not quite reach the hind margin. Frontal and facial callosities black; third and fourth abdominal segments with four black longitudinal spots, alternating with yellow ones, sometimes coalescing in such a way as to leave but a yellow longitudinal stripe and lateral yellow spots.

Length, 8–9 mm.

Female. Face yellowish-ferruginous, facial callosities black; palpi reddish-yellow; front, antennæ and thorax as in the preceding species. Abdomen: first two segments yellow; the first with two black, rounded spots, separated by a yellow space, under the scutellum; the second with two short, diverging black streaks in the middle, which neither meet nor touch the anterior margin; the posterior margin they sometimes touch, sometimes not; the third

segment shows four longitudinal spots on yellow ground; sometimes these spots expand at both ends in such a manner as to leave only a longitudinal yellow stripe in the middle, and a round yellow spot, on black ground, each side; the fourth segment is colored like the third, so that in some cases the abdomen shows two longitudinal black stripes, reaching from the scutellum to the posterior margin of the fourth segment, and two lateral stripes on the third and fourth segments; in other cases (and, upon the whole, more frequently), the third and fourth segments may be described as black, with a yellow median stripe and, on each side, yellow spots, a pair on each segment. The last segments are black, with yellow hind margins, the fifth sometimes with a yellow median line. Venter yellow; third and fourth segments with black spots in the middle (which are nearly obsolete in some specimens), and blackish lines on the sides; the fifth and following segments black, with yellow margins. Legs as in *C. montanus* and also variable as to the extent of the black color. Wings: both basal cells hyaline, the brown color encroaching but very little upon either of them; crossband not quite filling out the fourth posterior cell, and leaving a hyaline space at its distal end and along the intercalary vein; a brown shade on the last section of the fifth vein is hardly perceptible; the hyaline triangle between the crossband and the apical spot entirely separates both and reaches the costa with its apex.

Hab. Pennsylvania; Massachusetts; White Mountains, N. H. (Scudder); Canada (Couper); Kansas (Al. Agassiz). Twelve female specimens.

22. Chrysops fallax n. sp.

♀. Apical spot separated from the crossband by the tip of the hyaline triangle, which almost reaches the costa; both basal cells hyaline; *the crossband reaches the posterior margin.* Facial callosities reddish or brownish, third and fourth abdominal segments with four black longitudinal spots, alternating with yellow spaces, the black sometimes coalescing in such a way as to leave but a yellow longitudinal stripe in the middle. Length, 7–7.5 mm.

Female. Very like *C. hilaris*, but with the following, apparently constant, differences: it is smaller; the end of the crossband fills out the fourth posterior cell, or very nearly so; although the hyaline triangle between crossband and apical spot crosses the second longitudinal vein, forming a large hyaline spot in the marginal cell, still a connection is left between the crossband and the apical spot, in the shape of a narrow brown shadow; the cloud on the last section of the fifth vein is somewhat more distinct; on the abdomen, *the black spots under the scutellum, separated by a yellow space in* C. hilaris, *are here coalescent* (this seems to be a very constant character); the converging black lines on the second segment are sometimes coalescent anteriorly; the facial callosities are usually red, often brownish on their lower half; the cheeks are also variable, from reddish to black. The abdomen is like that of *C. hilaris*, and shows the same variations as in that species; in some specimens the third and fourth segments, except a yellow stripe in the middle, and a yellow hind margin, are entirely black.

Male. Similar to the female; the proximal ends of the basal cells somewhat infuscated; thorax with erect, yellowish hairs; third and fourth abdominal segments (in the two specimens before me), yellow, with four black spots; the following segments black, with yellow hind margins.

Hab. Cambridge, Mass.; S. Amherst, Mass. (G. Dimmock); Tarrytown, N. Y.; Delaware; Maryland. Twelve female and two male specimens.

Two female specimens which I took at the Trenton Falls, N. Y., in July, 1874, have black frontal tubercles, and the feet more black than usual. I hardly doubt the specific identity of these specimens.

23. Chrysops obsoletus Wied.

Chrysops obsoletus Wiedemann, Dipt. Exot., I, p. 108, 10; Auss. Zweifl., I, p. 211.

♀. The hyaline triangle separating the crossband from the apical spot reaches the costa; both basal cells hyaline; *abdomen brown, with a yellow, tapering, median stripe, which does not reach the tip, and two lateral narrower, and still more abbreviated stripes.*

Length, 6.5–8 mm.

Female. Antennæ black; more or less yellowish at the base; face yellowish-ferruginous, facial callosities black; front yellowish-gray, with a large, black callosity. Thorax with the usual greenish-gray median stripe, divided by a black line; yellowish lateral stripes and yellow stripes on the pleuræ. Abdomen more or less dark brown; a yellow stripe, tapering posteriorly, reaches from the base of the first segment to the hind margin of the fourth or even the fifth segment; two lateral, narrower, yellow stripes on the first and a portion of the second, sometimes even on the third and fourth segments. Venter brown, with more or less yellow on the sides of the first three segments; a brown lateral stripe often crosses the yellow. Legs reddish, with the end of the front tibiæ and the front tarsi, the ends of the four posterior tarsi, the base of the hind femora, etc., black. Wings: two basal, anal, fifth posterior cells and anal angle hyaline; crossband almost reaching the hind margin along the vein between the third and fourth posterior cells, but leaving a hyaline space on the proximal end of the discal cell and, in the fifth posterior cell, along the intercalary vein. The hyaline triangle between the crossband and the apical spot crosses the second longitudinal vein, and touches the costa; the apical spot is of a paler shade of brown than the crossband and evanescent posteriorly.

Hab. Pennsylvania; Maryland; Manlius, N. Y. (J. H. Comstock); Cambridge, Mass. (Sept. 19); North Conway, N. H. (August, 1874). Nine females.

In some specimens the lateral stripes of the abdomen become obsolete; in others, on the contrary, a trace of a prolongation is visible on the third and fourth segments. Wiedemann mentions a specimen from Pennsylvania, in which these stripes almost reached the end of the abdomen. Sometimes the brown tinge of the costal cell is very pale.

The male of this species, according to Wiedemann, has no stripes, either on the thorax or on the abdomen.

24. Chrysops plangens Wied.

Chrysops plangens Wiedemann, Auss. Zweifl., I, p. 210, 22 (♀).

Chrysops fuliginosus Wiedemann, Dipt. Exot., I, p. 109, 11; Auss. Zweifl., I, p. 210, 23 (♂).

♀. The apical spot is separated from the crossband by a hyaline lunule, reaching to the costa; first basal cell infuscated; the brown design on the wing is rather pale; body altogether grayish.

♂. Altogether blackish; wings pale brownish, with some faint paler streaks.

Length ♀, 6–8.5 mm. ♂, 6.5 mm.

Female. Head gray; face ferruginous in the middle, with black, shining frontal callosities, separated from the black, shining cheeks by a stripe of yellowish pollen; antennæ

usually blackish, with a vestige of reddish at the root of the third joint (compare the observation at the end of this description). Thorax blackish, with a broad gray median stripe, divided by a longitudinal blackish line; lateral grayish stripes above the root of the wings; pleuræ grayish, with a blackish stripe. Abdomen grayish, with faint bilobed blackish spots at the base of the segments; grayish golden hairs on all segments, especially on the hind margins; venter blackish-gray, hind margins of the segments lighter gray. Legs black; tibiæ, except the ends, and base of all the tarsi, brownish. Wings of a general grayish hue; second basal cell subhyaline; the usual picture pale brownish; it consists: 1, of the infuscated costal and first basal cells (except a small subhyaline spot at the distal end of the latter); 2, of a crossband not sharply limited by the intercalary vein, and rather evanescent posteriorly, coalescing with the general grayish hue of the anal angle; 3, of an apical spot, separated from the crossband by an oblique, subhyaline streak between the end of the stigma and the proximal end of the second submarginal cell; posteriorly, a space of a more grayish hue completes the lunule between the apical spot and the crossband.

Male. Face as in the female; body altogether blackish, gray stripes on thorax hardly visible; abdomen with a faint grayish pollen, and grayish golden hairs. Wings of an almost uniform grayish-brown tinge, with only a faint outline of the usual picture; a distinct hyaline streak between the end of the stigma and the proximal end of the second submarginal cell; a double subhyaline spot at the distal end of the basal cells.

Hab. Cambridge, Mass., midsummer; New Rochelle, N. Y.; Tarrytown, N. Y., in June; New Jersey. Six females and two males.

I possess, moreover, two females and a male, which I collected in Florida, in March. The females have the base of the first and second joints of the antennæ yellowish-red; in the male, the antennæ are altogether black; otherwise I do not perceive any difference between these specimens and those from the Northern States and take them for the same species.

In Wiedemann's description some clerical error was committed in the description of the antennæ, as "yellowish antennæ with a black basal joint," seem somewhat improbable in a *Chrysops*; moreover, Wiedemann himself describes the antennæ of his *C. fuliginosus*, ♂, as "black, with a brownish-yellow root," suggesting at the same time the synonymy of this species with *C. plangens*, ♀.

I have never seen the following North American species of *Chrysops*: —

1. **Chrysops lugens** Wiedemann, Dipt. Exot., p. 109; Auss. Zweifl., I, p. 212 (Savannah).

For some time I felt inclined to identify this species with the dark specimens of *C. morosus*, mentioned at the end of the description of that species. But Wiedemann describes his species as "black" and not brown, which cannot possibly apply to the darkest specimens of *C. morosus*.

2. **Chrysops nigripes** (Zetterstedt); Loew, Verh. Zool. Bot. Ges., Wien, 1858, p. 623.

Occurs, according to Loew, in Lapland and also in Sitka (erroneously called (l. c.) "the peninsula Sikka"). It belongs to the group with an apical spot.

3. **Chrysops quadrivittatus** Say, J. Acad. Phil., III, 33, 1 (1822); Wied., Auss. Zweifl., I, p. 200, 9. Rocky Mts.

4. **Chrysops sepulchralis** Kirby, Fauna Bor. Amer., p. 314, 1.

Whether it is really identical with Fabricius's species of that name, remains to be proved; this identification certainly shows that the species belongs to the group provided with an apical spot.

SILVIUS.

The only North American species of this genus hitherto described, *S. isabellinus* Wied., I have never seen. The following species is a true *Silvius* from the Pacific basin; it differs, however, from the European species in the presence, on the face, of shining black callosities.

Silvius trifolium n. sp.

♀. Thorax clothed with a dense yellowish pollen, abdomen reddish-yellow, at the base with three elongated blackish spots, connected at their ends in the shape of a clover-leaf.

Length 11.5 mm.; wing 10.5 mm.

Head grayish-yellow, from a dense pollen which covers it; small areas round the ocelli, an obcordiform frontal callosity and two regular spots on the face, below the antennæ, shining black. Antennæ: two basal joints and base of the third, reddish-yellow, the remainder black; palpi reddish-yellow. Thorax: ground color black, but altogether concealed under a thick grayish-yellow pollen: pleuræ with yellow hairs. Abdomen reddish-yellow, somewhat purer yellow on the posterior margins of the last segments, clothed with some appressed minute black hairs; the posterior margins of the segments show traces of a fringe of yellow hairs; the first segment has a blackish spot in the shape of a recumbent, elongated 8, both lobes of which are situated on both sides of the scutellum; on the second segment, in the middle, there is an elongated spot of the same color, which, with the spots of the first segment, forms a figure not unlike a clover-leaf; these spots are clothed with yellowish pollen. Venter reddish-yellow, with a trapezoidal black spot at the base. Feet reddish-yellow; knees, tibiæ and tarsal joints tipped with brown: tarsi altogether brownish towards the end; hind tibiæ beset with black hairs. Wings hyaline with a grayish tinge; the base, the costal areas and stigma tinged with yellow; the fork of the third vein has a stump of a vein.

Vancouver Island (G. R. Crotch); Washington Territory. Two female specimens.

HÆMATOPOTA.

Besides *H. punctulata* Macq., Dipt. Exot., I, 1, p. 163, from the Carolinas, which I do not know, the following species occurs in North America, and seems to be very common in the Northwest.

Hæmatopota americana n. sp.

Female. Grayish-black, variegated with white lines and spots; wings grayish, with numerous irregular white streaks and a large ocellar spot, having the base of the second posterior cell for its centre. Antennæ black, first joint very much incrassated, the third somewhat pale at the extreme base only; a large, shining, black, transverse callosity above them; two velvety black spots above the callosity. Feet black; front tibiæ

at base, middle and hind tibiæ at base and in the middle, with a broad white ring; first joint of middle and hind tarsi white, the tip black. Abdomen with two white spots on each segment, beginning with the third and with white posterior borders, dilated in the middle.

Length, 10–11 mm.

This species is almost identical with the European *H. pluvialis* (compare the description and the figure in Meigen, Syst. Beschr., II, p. 60, Tab. 14, f. 8–16). A constant difference seems to exist in the coloring of the third joint of the antennæ, which is altogether black, except a slight vestige, often invisible, of a paler coloring at the base of the third joint, while the European specimens have the first half of the third joint more or less tinged with reddish. The first antennal joint in all my specimens is stouter than in the European specimens which I have for comparison; the front seems broader; there is no vestige of the longitudinal white line along the middle of the abdomen, which usually exists in European specimens; the white picture of the wings seems to be more marked and the design more fully carried out. However, in Europe this species is very variable and I have only a few European specimens for comparison.

Fort Resolution, Huds. B. Terr. (R. Kennicott); Lake Superior (A. Agassiz); Dacota (Dr. Coues); Southern Montana; British Columbia (Crotch). I have compared more than two dozen specimens.

DIABASIS.

Established by Macquart in the *Suites à Buffon* and in the *Diptères Exotiques*, this genus does not seem to be sufficiently defined; except the shortness of the face, in connection with it, the rather low insertion of the antennæ, and the rather broad fore tibiæ, there seems to exist no appreciable character to distinguish it from Tabanus. It may be that some of the characters mentioned by Macquart (for instance the callosities on the face) occur in the other species which he places in the genus, but they do not exist in the only known North American species.

As it is, *Diabasis ferrugata*, besides its general appearance and coloring, which are not Tabanus-like, has only the coloration of its eyes to show, as a distinctive character. The direction of the stripes of the eye is very oblique, almost from top to bottom, instead of nearly horizontal, as in Tabanus. A purple stripe runs, between two green ones, from the vertex downward, across the eye; from the inner one of the green stripes, a green band, perpendicular to the stripe, runs crosswise toward the antennæ, dividing in two the inner and lower portion of the eye, which is purple.

Diabasis ferrugata.

Chrysops ferrugatus Fabricius, Syst. Antl., 111, 2.
Tabanus ferrugatus Wiedemann, Dipt. Exot., I, p. 94, 56; Auss., Zweifl., I, p. 186, 113.
Dichelacera ferrugata Walker, List, etc., I, p. 191 and V, p. 148.
Diabasis atonia Macquart, Dipt. Exot., I, 1, p. 152 and Walker, List, etc., V, p. 271.
Chrysops approximans Walker, List, etc., I, p. 198.
Chrysops convergens Walker, List, etc., I, p. 198.
Tabanus americanus Palisot de Beauvois, Dipt., Tab. III, f. 6.
Tabanus Rondanii Bellardi, Saggio, etc., I, p. 68, Tab. II, f. 11.

Female. Yellow; thoracic dorsum grayish, tip of the abdomen brown; tip of antennæ, front tibiæ and tarsi black; wings brown at the apex and with a brown stigma. Length, 9–10 mm.

Palpi and antennæ ferruginous-yellowish; the end of the third joint of the latter blackish or brown; face grayish; front comparatively narrow, yellowish above the antennæ, grayish above the callosity and yellowish-gray toward the vertex; callosity nearly square, blackish or black. Thorax yellowish; the middle portion of the dorsum is grayish, which color is tempered by a yellowish pollen; pleuræ and pectus, in part, gray. Abdomen ferruginous-yellowish, clothed with a golden-yellow pubescence; sixth segment brown on the sides; seventh entirely brown; (in some specimens the preceding segments also show a brownish tinge on the sides). Distal third of the front femora, the front tibiæ and tarsi black; distal half of the middle tarsi brownish; hind tarsi, except the base, and hind tibiæ, more or less brown (the hind tibiæ seem to vary in the intensity of the coloring; in one specimen they are brown, except at the base; in another the brownish coloring is hardly perceptible at all; the third holds the middle between the two); the remaining portion of the legs is yellow. Wings subhyaline; stigma brown; the apex, immediately beyond the tip of the second vein, is brown; this tinge becomes much fainter, however, toward the hind margin; a faint brown tinge in the proximal half of the first posterior cell encroaches more or less on the first basal cell and extends along the central crossveins; costal cell yellowish.

I have four female specimens before me; two from Florida and two from Mexico. One of the latter has the hind tibiæ brown except at the base.

This species occurs also in the Carolinas (Macquart), in the West Indies and Honduras (*Chrysops convergens* Walker), and in Brazil (Macquart).

The synonymy embraces not less than *six* specific names; Mr. Walker, in his List of the Diptera of the British Museum, after having identified it once as *Dichelacera ferrugata*, describes it *twice* as a new species, and quotes it a fourth time as *Diabasis atœnia*. The descriptions of *Chrysops convergens* Walker, and *approximans* Walker, which are beside each other, are absolutely identical; a slight difference appears in the hind legs, the coloring of which, as I have shown, is variable. The other synonymies will not seem in the least doubtful to any one who will take the trouble to compare them.

XIV. Revision of the North American Poriferæ; with Remarks upon Foreign Species. Part I.

By Alpheus Hyatt.

Read November 18, 1874.

THE series of Memoirs, which the following introduces, was undertaken in order to prepare a catalogue of the Poriferæ in the Museum of the Boston Society of Natural History. It was found, however, that nothing less than an accurate study of all the forms which could be obtained from all the neighboring Museums would serve to throw light upon the subject. The principal merit of these Memoirs will consist in the completeness of the list of species from Florida which were gathered by Dr. Palmer.

This collection enabled the author to revise the only work which has yet been issued upon the sponges of Florida, "Spongiaires de la Mere Caraïbe," and to identify with approximate exactitude the majority of the numerous species therein described. The discovery of the rich and varied poriferous fauna of Florida compensates for the hopeless confusion which has been momentarily caused in the minds of spongologists by the careless descriptions and imperfect figures which fill its pages. These deficiencies will irritate the mind of every reader, but it should not be forgotten that we owe to the authors some acknowledgment for their patience in collecting and describing so many new forms, whatever we may think of the ability displayed in their subsequent attempts at systematic work.

The collections of the Museum of Comparative Zoology, containing the types of Schmidt's work upon "Spongien Fauna d. Atlantischen Gebietes" have been placed at my disposal by Mr. Alexander Agassiz. The fine collection at New Haven of New England and Florida sponges has been sent to me without reservation by Prof. A. E. Verrill. Many smaller collections, containing many valuable forms, have also been generously loaned. Among these are especially worthy of mention, the collections of the Peabody Academy in Salem, of Prof. Rice of Middletown, of Mr. R. F. Schor of Evansville, Ind., and of C. J. Maynard of Newton, Mass.

Order KERATOSA.

The characteristics of this order are more clearly defined than those of any other among the class Porifera, so far as the skeleton is concerned. It is therefore very curious to observe that the smaller divisions are here more difficult to define, the families and genera being especially close in their affinities. The order is strictly limited by most authors to those forms which have only keratose fibres and do not possess spicules, properly so called; *i. e.*, spicules developed within the integument or internal sarcode. Foreign matter and spicules of other sponges are frequently found in the different parts of the sponge mass, but they have been always introduced from without. The variation of form is very great.

The Janthellidæ are so very similar in form and in the size and aspect of the fibres, to both Antipathes and Gorgonia among the Corals, that when no animal matter is left upon the branches it is very difficult to separate them from the last named. On the other hand, we have the finest and most attenuated fibres and typical sponge structure in the fistular forms of the genus Spongia. So little is known of the purely anatomical characteristics of the internal parts of most singular forms, such as Janthella, that it would hardly be safe to attempt any generalization in this direction.

Sub-order APLYSINÆ Hyatt.

Sub-order IV Bowerbank.

Though Schmidt is disposed to discourage the use of a distinct name for this group, I find myself obliged to admit the hollow-fibred species to the rank of a distinct subdivision of the order Keratosa. The Aplysinæ appear to me a perfectly natural and very easily distinguished group. The skeleton is composed of anastomosing horny fibres, which are typically hollow, though not infrequently filled up by a granular deposit. This filling is generally of a light yellow color, except in *Aplysina aurea*, (in which it is absent, its place being apparently supplied by a thin membrane), and the fibres are therefore either transparent, or black and opaque. The enormous compound fibres of Janthella have neither membrane or yellow matter in the interior, and are also not continuously hollow. The horny matter is laid on in concentric layers, and these are quite loosely connected. Thus the walls of the inner tubes seem sometimes to have shrunk in the dried specimens until they touched and entirely filled the centre with a solid core; whether this also occurs in the living animal I cannot say. The horny material is deposited in concentric layers from without, and in some species, as in *A. cellulosa*, this deposition appears to continue indefinitely, the fibres becoming in course of time exceedingly broad. Usually also the terminations of the fibres near the exterior have much thinner walls than is found in the interior, the concentric deposits being thicker in the older portions of the sponge. This, in dried specimens, causes the collapse of the terminations of the branches and their peculiar irregular twisted aspect and almost black color in some species.[1] The fibres of Verongia are exceptions to this rule; they remain of about the same rotund form in all parts. The variations appear to be in the extreme thickness of the walls of the older fibres, though this increase is never so excessive as in *Aplysina cellulosa*.[2]

DENDROSPONGIADÆ.

This family is characterized by the irregular anastomosis of the fibres of the skeleton, their rotund form, and the thickness of the horny walls.

Dendrospongia Hyatt.

Aplysina (pars) Schmidt.

One specimen from the Museum of Comparative Zoology is named by Schmidt as *Aplysina œrophoba ?*. It is fistulose and not very different outwardly from the true *A. œrophoba*, though the surface is much rougher and shows coarse spiniform projections in place of the

[1] Pl. 13, fig. 7.

[2] Pl. 13, fig. 19.

continuous fine ridges of that species. The skeleton, however, at once settles the question of identity. It is composed of excessively coarse fibres, hollow, or more or less filled, as in most parts, with layers of granular matter. These may be either concentric, and fill it up more or less solidly, or only line the tube,[1] or, as in some instances, stretch as flat partitions across a series of constrictions which cut up the tube into bead-like cavities. The reticulations of the skeleton are of the simplest known form, being coarse, irregular and tree-like to the last degree. The figure[2] represents the fibres which support a fistulose projection from a colony, and it may be seen that the skeleton is but just sufficient to support the sarcode and that no regular web or mesh is formed as in Aplysina. The ends of the fibres are free and project considerably, causing the spiniform elevations of the surface described above, but do not pierce the outer skin in carefully dried specimens. This is owing to the thick, tough character of the cuticular layer which is not easily pierced. The sarcode itself in the interior is very abundant and solid, as seen in alcoholic specimens. Very minute spines were occasionally seen attached to the surface of the cuticular layer, but they may have been accidental.

Dendrospongia crassa Hyatt.

Aplysina aerophoba Schmidt (pars). Spong. d. Atlant. Gebiet., p. 30.

A curious resemblance is produced between the exterior of dried specimens and *Aplysina aerophoba* by the toughness of the external membrane. This forms ridges extending from the apices of the branches and thus cuts up the surface into more or less angular pits resembling, though not so deep as, those due to the honeycomb-like cells of Aplysina. The forms which I have seen may be either fistular or irregularly shaped solid masses, with occasional large excurrent openings. The color, according to Dr. Palmer, in nature is very dark, almost black, and in alcohol it is dark purple. The fibres are of very large size and may be followed in continuous lines for long distances.[3]

Nassau, 12 feet, coral reef. Soc. Coll.

VERONGIA Bow.

Luffaria Duch. et Mich.
Luffaria Schmidt.

This genus was described by Bowerbank first in 1841 in the Annals and Magazine of Natural History, and subsequently in his British Spongiadæ. He distinctly states that his type is *Spongia fistularis* Lam., an unmistakable species which is placed by Duch. et Mich. in their genus Luffaria. This genus Schmidt adopts in his Spong. d. Atlant. Gebietes, thus suppressing the name Verongia which he had previously published as a synonym of *Aplysina Nardo* in the Spongien d. Adriatischen Meeres, III Suppl., 1866. The channels of the interior of the fibres are very much smaller than in Aplysina and the anastomosis of the fibres occurs at irregular intervals. The direction of the whole is determinable as a radiatory arrangement but still the effect is that of a solid but excessively irregular net work. This is owing to the fact that the growth of the fibres takes place over the whole exterior surface at once. The frame work is formed by the simultaneous growth of projecting fibres over the

[1] Pl. 13, fig. 1.
[2] Pl. 13, fig. 7.
[3] Pl. 13, fig. 7.

whole external surface,[1] which at certain intervals throw out two lateral branches. These anastomose in all directions with the tips of the branches from the neighboring fibres. The growth of new branches takes place by a bud from the point of junction of these new ones, and the resulting branch therefore seems to spring from the upper side of the next lower mesh. This is the general mode of growth, but, as may be seen by the figure,[2] more than one bud may result from the union of the branches of the fibres, and sometimes these may remain undeveloped. The cavities, as may be seen by reference to the same figure, are larger in proportion to the diameter of the fibres among the new growth on the right of the figure, and the walls are thinner; but so far as I saw, this is attended by no change of form even in the dried specimens.

Verongia fistularis Bow.

Spongia fistularis Esper, Pflanzenthiere, vol. 2, pl. 21, A.
Spongia rigida Esper, Pflanzenthiere, vol. 2, pl. 27.
Spongia rigida Lam., Anim. sans Vert., vol. 2, p. 367.
Luffaria rigida Duch. et Mich., Spong. Mer. Car., p. 60.

The variety of forms under which this species appears has entirely misled Duchaissing and Michelotti, who have described them as distinct. Schmidt is evidently inclined to unite them, though his means of information were not complete. I have, however, had the good fortune to see a specimen from Bermuda belonging to the collection of Prof. Rice of Middletown, Conn., which completes the circuit of the extreme forms in itself.[3] It is a pair of fistular tubes equivalent to *Luffaria fistularis* D. et M., united only at the base. The long one is almost surrounded by various small solid stems equal to *Luffaria fulva* and *L. applicata* D. et M., which spring from its sides and top and are themselves branching. The large tube is also quite deeply indented and the sides are unusually thick, thus approximating to the forms described by Duch. et Mich., as *Luffaria rupicola* and *L. unciformis*. The reason of the extreme variation of form in this species seems to me to lie in the adaptability of the skeleton to any form which may be best suited to the location taken possession of by the floating germ. Accident determines the form, and the range is not limited or determined, as in some other species, by the peculiar structure of the skeleton.[4] The fibres themselves are subject to considerable variation. They are thicker and more brittle in some forms than in others, and even differ in the same specimen. Usually the difference occurs between the older and younger fibres,[5] the fibres externally being somewhat smaller than the internal ones, or these than those nearer the base. But sometimes contiguous spots on the same specimen may exhibit the greatest difference in the size and thickness of the fibres.

The variation in color must also be very great, since the form described as *Luffaria fulva* by Duch. et Michel. as of a yellow color, is said by Dr. Palmer to be dark purple, while the *Luffaria applicata* he collected was of the usual bright yellow. It may be that the smaller forms, such as *Luffaria applicata* D. et M., grow only in the shallows, *Luffaria fulva*

[1] And in the fistular forms, this springing out of new branches takes place over the internal surface also. The result of this method of growth greatly increases the thickness of the walls at the expense of the diameter of the tube. It must be remembered, however, that this method of growth is combined with a steady addition to the height of the tube, which is much less in those which have very thick sides than in those with thin sides; the variety *rupicola* represents the former mode of growth, and the variety *Schm* the latter.

[2] Pl. 13, fig. 19. [3] Pl. 13, fig. 20.
[4] Pl. 13, fig. 11. [5] Pl. 13, fig 19.

D. et M. in somewhat deeper, say from eight to ten feet, and the fistular forms in the deepest waters. This view is suggested by Dr. Palmer's notes, he having collected the first-named varieties in the shallower water associated with Echinoderms and Star-fishes, and the branching forms, equivalent to *Luffaria fulva* D. et M., only in the deeper water associated with Gorgonia or Corals; and the skeletons of the last, equivalent to *Luffaria rupicola*, only when cast up by storms on the reef. Usually the tubular interior of the fibres remains smaller than in any species of Aplysina, but I have one specimen of variety *applicata* which shows in one portion fibres with thin walls while in other parts the usual proportions are maintained.

Cape Florida, Nassau, Bermuda. Soc. Coll.

Verongia hirsuta Hyatt.

Variety *fulvoides*. One specimen in the collection of the Museum of Comparative Zoology exhibits a very hirsute exterior. This is due to a sudden lengthening of the not yet anastomosed fibres which always project beyond the surface. Both branches also have subsequently to this curious variation given rise to a bud, which resumes in the formation of the skeleton the closer growth observable in the central parts of the parent stem. Another type of this fulva-like variety occurs in two specimens in the Society's Collection. These are equally hirsute, the points of the fibres standing out prominently all over the surface.

Variety *fistularoides*. The fistularian variety is represented in one specimen in the Museum of Comparative Zoology from Havana. This is the fragment of a very large specimen perfectly fistular, with thick walls, dark brown colored and large fibres, which dichotomize near the external surface, dividing into single branches of greater or less extent but forming no proper net-work. These are gathered into tuft-like prominences and appear sometimes to be a quarter of an inch deep. This curious surface renders the sponge entirely distinct from any other, though the forms of the varieties are the same as in *V. fistularis*.

Florida and Havana.

Verongia tenuissima Hyatt.

This species is founded upon a single specimen, but the characteristics are so different from even the most extreme variety of *Verongia fistularis* that I venture to describe it as distinct. The fibres are either round or slightly flattened, very much smaller than those in any variety of *V. fistularis*, but anastomose in the same irregular way. Though this is the case the mesh, nevertheless, in size and form approximates in the older parts of the specimen examined to the mesh of Aplysina, though there is no tendency to build up cells as in that genus. The form is fistulose, the single specimen examined being an irregularly shaped double tube, about an inch and a half high and two inches broad. The surface of the specimen in alcohol is softer and firmer than that of *Aplysina aerophoba*; it is studded as in *Verongia fistularis*, with projecting points, but has not the rough prickly feeling of that species. All of these characteristics are due to the greater elasticity of the fibres, their small diameter and the density of the skeleton. The shrinkage of the body is

not so great as in *Aplysina cærophoba*, the animal matter being sustained more fully by the skeleton.

Key West, in shallow water. Color unknown. Soc. Coll.

APLYSINIDÆ.

This family may be characterized by the regular net-like anastomosis of the fibres, the tendency of this to occur in the same plane, the flatness of the fibres, and the thinness of their walls.

Aplysina Nardo.

Evenor Duch. et Mich.
Aplysina (pars) Schmidt.

This interesting genus was first described in the Isis for 1833 as Aplysia by Nardo, who changed the name to Aplysina in 1834. Schmidt identifies the Florida specimen, described on the following page, as the *Aplysina cærophoba* Nardo, a Mediterranean form. However this may be, there is one expression in Schmidt's description of the true *Aplysina cærophoba* of the Mediterranean which seems to settle, at any rate, the true, generic name of the Florida specimens described below.[1] He describes the peculiar network and says that, in this respect, the genus differs from all others. The peculiar structure is due to the anastomosing of the fibres at regular intervals and in the same plane, thus forming a net work with a mesh, which may be either regular or very variable in size.[2] The net-like walls thus formed anastomose with each other at intervals of greater or less extent according to the species; in some species forming elongated cells, and in others angular cells like those of a honey-comb; or better still, they may be compared closely with Porites, as Ellis and Solander have done in their plates of *Aplysina cellulosa*. The genus Evenor as described by Duchaissing and Michelotti either belongs to this genus or is a new genus intermediate between this and Dendrospongia. It is, of course, impossible to say anything positively because the authors have given so little besides the mere external characteristics of the skeleton and living sponge. These, so far as they go, indicate a species of Aplysina, which differs in form, and perhaps in the skeletal characteristics, from all others yet described.

Aplysina aurea Hyatt.

This remarkable species is described by Dr. Palmer as having a brilliant gamboge yellow color when living; but when dried it is of the same purplish black, though of a somewhat lighter shade, as in the preceding species. In drying it shrinks excessively and will, according to Palmer, unless frequently turned, melt into a solid mass, losing entirely its natural aspect. The dried specimens show quite a complete series from the young, which are single, short, fistulose tubes, to those six or seven inches long, composed of more or less irregularly shaped masses of similar conical tubes. The aspect of the dried specimen is quite similar to the figure of the dried *Spongia fenestrata* Duch. et Mich., but this is described as black when living. The meshes of the net-work of the fibres are exceedingly

[1] "Die Fasern sind stark, ziemlich elastisch und bilden ein unregelmässiges, ziemlich weitläufiges Maschenwerk. Schon ihrem Bau nach sind sie total von denen der anderen Gattungen verschieden."

[2] Pl. 13, figs. 12–14.

small and the whole resembles a honeycomb with small cells and walls of the finest lace.[1] The fibres are deficient in yellow filling.

Nassau. Soc. Coll.

Aplysina prætexta Hyatt.

The difference between this and the preceding species lies principally in the larger size of the areas or honeycomb-like tubes inclosed by the net-like walls. These are so large and elongated that the honeycomb-like aspect of the surface of the skeleton is destroyed. There is a similar but very slight elongation of these openings near the outer edge in *Aplysina gigantea*, but in this species the honeycomb-like structure is only irregularly maintained near the point of attachment on the inner side. The fibres themselves are thinner, more delicate, and more elastic.[2] The filling of yellowish matter occupies less of the whole extent of the tubular interior of the fibres, which are black and empty to a much greater depth than in *Aplysina gigantea*. The honeycomb-like openings have the same structual character as in the preceding species, but both sides are much rougher and more deeply indented in the dried specimen, owing to the greater openness of the supporting skeleton. The form is similar to *Aplysina gigantea*, which in all probability varies from flabellate to cup-shaped, according to the surface upon which it grows.

Nassau, 12 ft. on reef. Soc. Coll.

Aplysina gigantea Hyatt.

In this species the net work of the fibres in passing outwards, changes from an extremely coarse and elongated mesh to a finer texture of attenuated and dark horny fibres destitute of the yellow granular filling which gives a yellow tinge to the internal fibres.[3] The honeycomb-like tubes radiate from the centre outwardly, being shorter on the lower than on the upper side of the specimens. The specimens examined were parts of a large cup-shaped sponge with sides about eighteen inches broad, about ten inches deep in the centre, and diameter unknown. It is described by Dr. Palmer as a deep cup growing on the reefs, attached in such a manner to the irregular surface of the rock that the diver was only able to detach the specimen in fragments. One of these shows the centre of the cup which is hollowed out on the upper side. From this centre and from the other points of attachment on the lower convex side large folds or irregular thickenings of the surface radiate toward the circumference, the upper side being more plainly concave with fewer and more depressed foldings. The lower side in the dried specimen is very cellular, owing to the falling in of the external membrane, every cell being marked by a blind sac reaching nearly or quite to the centre. The excurrent openings are, however, rare on the convex side, though very numerous on the concave side. Portions of the convex side of this specimen exhibit the condition described by Dr. Palmer in the living animal, when the dividing walls of the honeycomb-like cells project slightly above the external membrane, cutting up the surface into polygonal figures in place of the deep cells described above. On the concave side those portions of the surface which intervene between the numerous excurrent orifices maintain nearly the aspect of the surface in the living sponge, while the orifices themselves have, in most cases, been very much enlarged. The color, according to Dr. Palmer, is purplish black.

Nassau, 12 feet on reef. Soc. Coll.

[1] Pl. 13, figs. 3, 4, 5, 6.

[2] Pl. 13, figs. 12–15.

[3] Pl. 13, figs. 8–14.

Aplysina ærophoba Nardo? Isis. 1833–34.

Aplysina ærophoba Schmidt, Spongien d. Adriat., p. 25, pl. 3, fig. 2, 1862, etc.
Aplysina ærophoba Schmidt, Spongien d. Atlant., p 30, 1870.

The types of this species, as determined by Schmidt, are in the Collection of the Museum of Comparative Zoology.[1] These I have examined. They consist of two specimens, which belong to two distinct genera. Schmidt probably identified them with *Aplysina ærophoba* Nardo, a Mediteranean species, without examining the skeleton of more than one specimen, which if not identical with, is doubtless very closely allied to, that species. The difference is shown by a comparison of the two figures given by Schmidt, one of the Mediterranean or undoubted *Aplysina ærophoba* in the "Adriatischen Spongien," and one of the Florida form in "Spongien Fauna d. Atlantischen Gebietes." The former seems to have a thinner wall to the fibre and to be filled up with solid granular matter, whereas the latter seems hollow, or only lined with a layer of granular matter. The former also seems to be rounded while the latter is flattened.

Schmidt nowhere describes the peculiar arrangement of the network or the variation in size of the meshes near the surface as compared with the interior. This net-like web of the fibres and the honeycomb-like arrangement of the walls formed by the web is as plainly shown as in any other species of the genus. The formation of the smaller meshes near the surface is by no means so well marked as in other species, but it is developed on some parts of the specimen. The size of the fibres, the size of the mesh and of the honeycomb-like tubes is smaller than in *Aplysina gigantea*;[2] the form of the specimens described by Schmidt and the form of the single one examined by me was fistulose, the fistular craters arising out of a solid basal mass. There were two fistular projections in a specimen about two inches long in the Collection of the Museum of Comparative Zoology, Cambridge. No figures of the fibres in section have been given, but those given for the form of the fibres in *Aplysina gigantea* are similar though much larger.

Florida. Mus. Comp. Zool.

Aplysina cellulosa.

Spongia cellulosa Esper, Pilanzenthiere, vol. 3, p. 206, pl. 60.

The peculiar formation of this sponge, the coarseness of the fibres and the typical character of the comb-like cells are very well depicted in Esper, and also Ellis and Solander's figures. A single specimen from an unknown locality is in the collection of the Peabody Academy of Science at Salem. This is too closely similar in all respects to the figures to leave any doubt of its identity, but it is somewhat curious that no one has yet been able to cite the locality. The specimen has been much beach-worn and it can only be seen that the fibres differ greatly in size on one side from those on the other.[3] The internal filling of granular matter is abundant, and the fibres therefore opaque and yellowish along the centre, with thick, dark, horny walls.

[1] The specimens were *Aplysina ærophoba* Ndo., and *Dendrospongia cavernosa* Hyatt.

[2] Pl. 13, figs. 10 and 16.

[3] Pl. 13, figs. 13, 17, 18.

JANTHELLIDÆ.

This group was first described by Dr. J. Edward Gray in 1869 in the Proceedings of the Zoological Society of London. The specimen, of which a description is given below, and Gray's own description, shows that the group has really a family value as he supposed.

The fibres are of enormous size when compared with those of the preceding group, and are destitute of the yellowish filling found in the Dendrospongiadæ and Aplysinidæ. Though typically hollow they are in part often solidly filled by the concentric layers of horny material. The exterior of these fibres is coarsely granular, and they are very opaque. The aspect of the dried specimens, as described by Gray, is very characteristic. Instead of being massive they are frondose. The sarcode, as in the Aplysinidæ, shrinks down closely upon the flattened trellis work of the skeleton and covers the huge fibres with a thin tenacious coating, which spreads across the broad interstices or mesh of the fibres, and is here and there pierced by canals which pass entirely through it. Gray describes the stem, "root," as composed of interlaced filaments from which the fibres of the frond spread out in all directions. All of the species which he describes, viz., *Janthella flabelliformis*, *basta*, and *Homei*, seem to have been either flat, as in Gorgonia, or modified into a funnel shape; the fibres also were smooth apparently. It will be seen below that *Janthella concentrica* differs very much and can only be provisionally referred to the same genus.

JANTHELLA.

Janthella concentrica Hyatt.

The description of *Janthella Homei* Gray applies very well to this specimen, but as there is no positive notice of the most prominent characteristics of this species I must consider it a new form. The fibres are of enormous size, being from one to three mm. in diameter. The youngest or the outer portions are single, but the inner branches are compound and ornamented with thick, short spines and more minute wart-like prominences. The compound fibres are made by the frequent tendency of the fibres to divide into branches which run side by side for long distances before they separate. As a result of this, and the freedom with which keratose matter is deposited, we find the fibres almost always double, or when joined by other branches, still more numerous, though contained within common layers of horny material and externally appearing as but one stem. The spines are, also, in reality only the terminations of abortive branches which run parallel with the fibres from which they sprang, and are closely united with them for a short distance but have free tips which protrude out of the common covering like the end of a young thorn. The type specimen is in the Collection of the Museum of Comparative Zoology, and is only a fragment, but it shows that the sponge must have been very irregularly frondose. The mesh is also quite irregular in size and shape, varying from 11.6 mm. to only 5 mm. in length, while the breadth varies from 3 to 6 mm. The specimen appears under the name of *Antipathes flabelliformis*, but whether the same as Dana's type or not I have no means of determining.

Fejee Islands. U. S. Ex. Expedition.

Explanation of Plate xiii.

Figs. 1, 2. 7. *Dendrospongia crassa.*

Fig. 1. Single fibre × 8 showing the interior, with lining deposit, concentric form of this deposit, and what appeared to be a particle of foreign matter imbedded in the interior. The concentric structure of the horny walls is well shown in this and in figure 2.

Fig. 2. Section of same fibre × 8.

Fig. 7. Skeletal supports of one fistular projection or projecting excurrent orifice of a solid specimen. Natural size.

Figs. 11, 19, 20. *Verongia fistularis.*

Fig. 11. Section of skeleton, natural size of variety *applicata.*

Fig. 19. Portion of the same × 8 showing the growth of new fibres externally and the irregular characteristics of the anastomosis of the fibres, also their round form by the accompanying transverse section "a".

Fig. 20. Reduced to two thirds natural size of specimen, combining characteristics of varieties *fistularis* and *rupicola* "d" and *applicata* "a" and *fulva* "b, c".

Figs. 3, 4, 5, 6. *Aplysina aurea* Hyatt.

Fig. 3. The side of one of the honeycomb-shaped cells, natural size.

Fig. 4. The same × 8 in outline merely, the internal tube is not drawn.

Fig. 5. Transverse sections of dried fibre showing variation in form.

Fig. 6. Broken fibre exhibiting the lining very much contracted, twisted and projecting beyond the end "a".

Figs. 12, 15. *Aplysina prætexta* Hyatt.

Fig. 12. Natural size of the side of one of the cells.

Fig. 15. A portion × 8.

Figs. 8, 9, 14. *Aplysina gigantea* Hyatt.

Fig. 14. Natural size of the side of one of the cells.

Fig. 8. A portion of Fig 14 × 8.

Fig. 9. Sections of fibres showing the variation of form.

Figs. 10, 16. *Aplysina aerophoba* Nardo.

Fig. 10. Natural size.

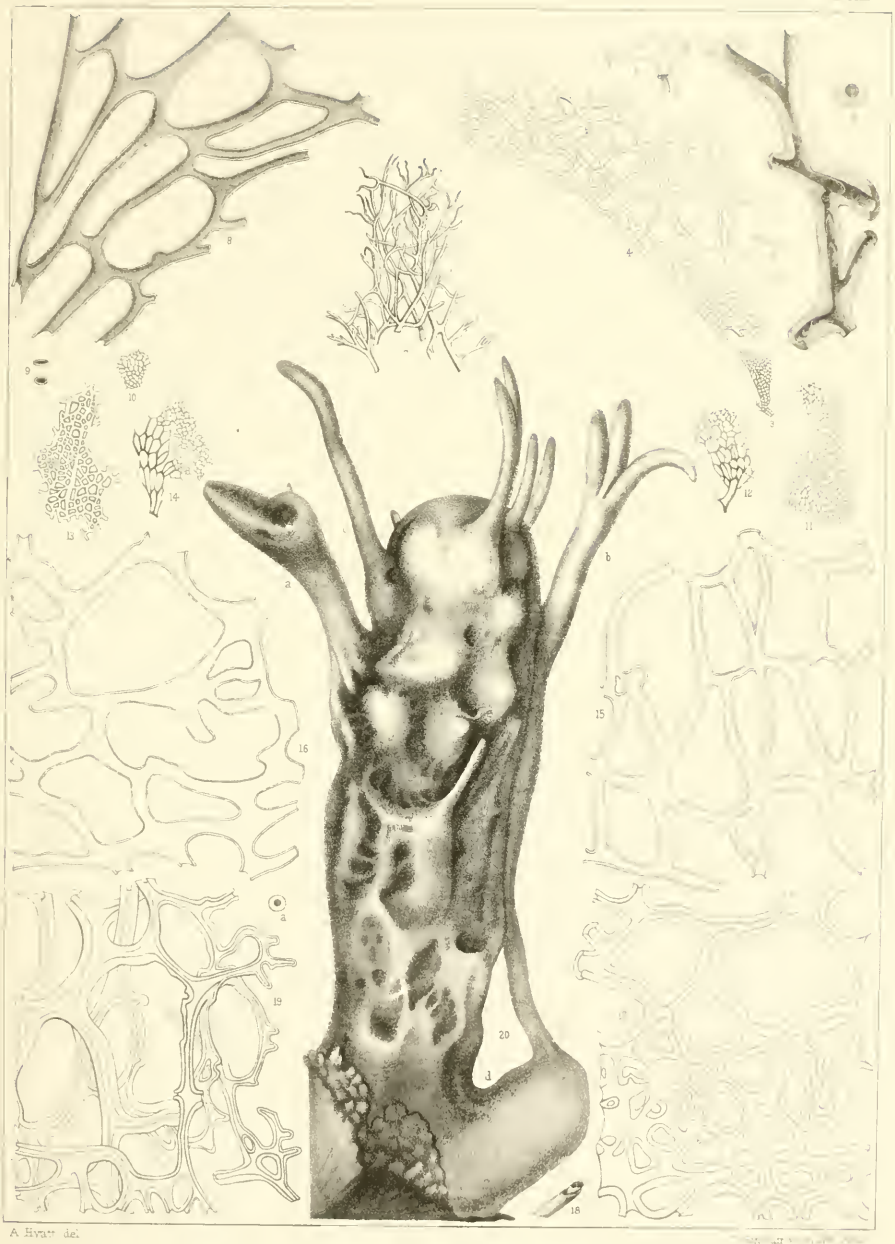
Fig. 16. × 8.

Figs 13, 17, 18. *Aplysina celludosa* Hyatt.

Fig. 13. Side of one cell, natural size.

Fig. 17. Shows thickness of some of the fibres and the complete filling up of some of the smaller meshes on the left of the figure by the external concentric deposits of keratose "a".

Fig. 18. Exhibits the solid filling of granular yellow matter, which is found in this and many other species of the Aplysinæ, projecting from a broken tube.



A Hyatt del.

A HYATT ON THE SUB-ORDER APLYSINA

XV. On Gynandromorphism in the Lepidoptera. By A. S. Packard, Jr., M.D.

Read February 17, 1875.

THE immediate object in the preparation of this paper is the description of an interesting case of "hermaphroditism" brought to my notice by Prof. S. A. Forbes, in charge of the Museum of Normal University, Normal, Illinois, to whose kindness I am indebted for the opportunity of examining this remarkable monstrosity which belongs to that Museum.

Regarding the circumstances under which it occurred, Mr. Forbes writes me as follows: "I have just heard from the collector of the cocoon from which was hatched our hermaphrodite *C. Promethea*; and although the history of the specimen was not remarkable, I send you the details. The chrysalis was taken from a bush near Evansville, Ind., on the 27th of November of last year, kept, I do not know how long, in a 'glass case' and afterwards sent to me. Of the other chrysalides of the same lot eight hatched males and four females."

Female Gynandromorph of Callosamia Promethea. The antennæ on the right side are of the usual length and width (width .13 inch); the lower pectinations are a little shorter than those on the upper side. The pectinations on the upper side, which are usually honey-yellow, are nearly as dark as the normal dark ones. These, however, vary in the same way in normal specimens. The left antenna is female, and the pectinations are of the same length as in the normal females; the branches arising from the base of each joint are dark, while in the normal female they are pale yellow, like the pair arising from the distal end of the joint. The front of the head is like the female, the eyes are quite unlike each other, that on the right side being much fuller, more globular than the left eye. I can see no appreciable difference in the eyes of normal ♂ and ♀ examples. The two right wings are male in coloration, but both are shorter and much broader even than in the normal females, and of the same size and shape as the opposite pair. I give the following measurements of these wings compared with the normal male and female: —

	Length of fore wing.	*Breadth of fore wing.*	*Length of hind wing.*	*Length of body.*
Normal ♂	1.90	.95	1.50	.75
" ♀	1.90	1.02	1.50	1.06
Gynandromorph	1.70	1.00	1.42	1.08

The arrangement of the markings are like those of the male; the basal two-thirds of the wing is black brown, the scalloped line limiting the blackish portion externally is more distinct than in the normal male, and the scallops are much deeper. Beyond this line, the wing on the posterior third is suffused with blackish, and with tawny in front. The submarginal black line is much less deeply scalloped than in the normal male behind the first

two deep scallops near the ocellus. The ocellus is more like that of the female than of the male, the blue semicircle being much more distinct than in the normal male.

The hind wings are marked and colored as in the anterior pair, with the submarginal row of dumb-bell like spots obsolete and represented by faint reddish discolorations, being concolorous with the corresponding spots in the female. Beneath, the fore wings are as in the male, not differing essentially in color. The hind wings have the white discal spot nearly obsolete, and the submarginal row of spots nearly obsolete, but concolorous when present. The left wings are both female throughout, the markings rather more highly colored and with larger and more distinct discal spots on both wings than in the normal female with which I have compared it, but owing to the shortness of the wing, the extradiscal line is nearer the apex of fore wing than in the normal male, and in the hind wings the same line is a little beyond, rather than considerably within, the middle of the wing, as in the normal female. Beneath, both wings only differ from those of the normal female in the larger, better marked discal spots, the style of coloration being the same, except the difference in situation of the common extradiscal line.

The thorax and abdomen are reddish as in the female, except on the right half of the thorax and basal half of the abdomen, which is blackish-brown, as in the male; the blackish discoloration does not, however, quite reach the median line of the body; on the abdomen it recedes from the median line rapidly towards the middle of the body. This dark color extends beneath the insertion of the wings on to the side of the thorax, but there is a broad red patch on the right side of the thorax, while the right side of the abdomen is beneath entirely like the left side. The three pairs of legs are, on the right side, considerably smaller than on the left. The tibiæ are but little smaller, and differ in color from those on the left side, being of a dull sable brown. The most striking difference, however, is in the diminutive size of the tarsi, which are scarcely half as large as those of the left legs. The five tarsal joints and the claws are present and well formed, but very short and small, the entire tarsus of two front pairs of right legs not being much longer than the first tarsal joint of the male (the tarsi of the third pair of legs are broken off). The inequality of the two anterior legs is shown in Plate XIV, fig. 1, *c*, *d*. The right tarsus is about one-third shorter than the left; the first and fifth joints being about one-half shorter than in those of the opposite tarsus; the second and third joints also shorter, while the fourth is about the same.

The abdomen is as large and well developed as in normal gravid females, and is distended with eggs *equally on both sides*, as, though the specimen is dried, I was able to pick out with a sharp point an egg from each side, showing quite conclusively that the gynandromorphism has not affected the internal organs of generation. The eggs are of the normal size, being .08 inch in diameter. They are easily seen through the abdomen as in other dried, gravid females.

The external appendages (fig. 1, *b*, *c*) are symmetrical and do not differ from those of other normal females. The supra-anal bilobed plate is large, well developed and of the normal form, and so is the less deeply bilobed infra-anal plate. The ovipositor within consists, as usual, of two well developed rough projections closely approximate and alike on both sides.

As regards the external generative parts, then, the specimen is entirely female.

Male Gynandromorph of Callosamia Promethea. How a male specimen may be affected by this accident can be seen by an inspection of the drawing (Pl. XIV, fig. 2) of an individual of *C. Promethea,* contained in the collection of Mrs. Bridgham, New York, who had the kindness to allow Mr. Cassino to make a drawing of the upper surface for me, and to take notes concerning its peculiarities, which form the basis of the following description.

The individual is evidently a male, as may be seen on a comparison of the drawings of the two gynandromorphs.

The left antenna is male, the right female, the reverse of the case in the other specimen. The left front wing is exactly as in the normal male; the left hind wing exactly as in the female. The left side of the thorax is masculine next to the masculine fore wing. The remainder of the thorax and abdomen is lighter than in a normal male and darker than in a normal female. The entire right side of the moth appears like the female, but suffused with many dark, irregular patches.

The outline of the two right wings is the same as that of the normal female, with the addition of the dark patches, and were it not for the irregular blotches and slashes the wings would be strongly feminine. The only exceptions are a white spot on the hind wing, and a spot with a white border on the fore wing between the kidney-shaped spot and the thorax. The posterior part of the abdomen is rather more masculine than feminine. The under side of the specimen was not examined. This case was described by Mr. W. H. Edwards in the Proceedings of the Entomological Society of Philadelphia (IV, 380).

The two cases described above may be regarded as extreme examples of what may be called *peripheral gynandromorphism, i. e.,* where the trunk (head, thorax and hind body) are not affected, but only the appendages and scales, including the wings, feet and antennæ; the head and genitals not being affected.

The least marked example of peripheral gynandromorphism which has come under my notice is that described by Prof. Westwood, who states that "he had an Orange-tip butterfly, *Anthocaris cardamines,* which was female in every respect, except that on the tip of one fore wing were about a dozen of the bright orange scales which characterize the male."

I will not attempt to give a history of all the cases of gynandromorphism among the Lepidoptera. The bibliography of the subject prior to 1862 has been given by Dr. Hagen in his "Bibliotheca Entomologica." Since then a number of cases have fallen under the notice of entomologists. I will cite one which is noticed by Mr. Dunning in the "Transactions of the London Entomological Society" (Aug. 7, 1865). He describes a specimen of *Fidonia piniaria* "which was sexually a female, and the abdomen was apparently distended with eggs; the general color was midway between the colors of the ordinary male and female, but the size and markings were those of the male." This is similar to our example discovered by Mr. Forbes.

Professor Westwood in his "Thesaurus Entomologicus Oxoniensis" (1874) describes fourteen cases of gynandromorphism in Lepidoptera. They were not what are commonly termed hermaphrodite monstrosities, as he says that the body of the insect appears to be unisexual, the sexual divarication being confined entirely to the secondary sexual characters exhibited by one or more of the wings only.

In the hermaphrodite *Bombyx quercus* described and figured by M. Guenée[1] there is an

[1] Notice sur divers Lépidoptères du Musée de Genève. Mémoires de la Société de Physique et d'Histoire Nat. de Genève, XXI, 369, 1872.

intimate mixture of the two sexes, in which, however, the female form predominates. The antennæ are neither exclusively male nor female. The wings on the right side are a mixture of the two sexes, while those on the left are female with some masculine features. The abdomen in form, size and color was feminine and contained eggs. The external organs were feminine, but still the anal opening was very different from that of the ordinary female, and in some respects represented similar parts in the male. It will be seen above that these parts in the female *Callosamia Promethea* did not differ from those in the normal female. In M. Guenée's specimen we apparently have the external genital parts affected by the gynandromorphism.

I am not aware that any Lepidoptera have been examined with the internal genital organs affected, as the examples thus far have not been preserved in alcohol. The best defined cases of gynandromorphism are those described in the honey bee by Siebold.[1] In these cases the internal and external organs are mixed together much as the other external characters. The sting with its vesicle and gland was present, though soft, in the drone, and in females the ovaries and also the spermaries were present, though the ovaries contained no eggs.

As to the cause of gynandromorphism, Siebold's explanation that it is due to an imperfect fecundation of the ovum seems most probable; these cases seem to me to be paralleled by the occurrence of hybridity between two species, the result being an irregular fusion of the characters of both species. Both seem to indicate that sexual characters, as well as specific characters, are determined at the time of impregnation.

Explanation of Plate xiv.

Fig. 1. Gynandromorphous *Callosamia Promethea*, female.

1 *a*. Abdomen of gynandromorphous female denuded. 1 *b*, the same seen from above, 1 *c*, 1 *d*, fore legs on different sides of the same specimen, denuded.

Fig. 2. Gynandromorphous *Callosamia Promethea*, male.

All drawn on stone by Mr. S. E. Cassino.

[1] Zeitschrift für wissenschaftliche Zoologie, 1864, p. 73.

XVI. The Structure and Transformations of Eumæus Atala.

By Samuel H. Scudder.

Read February 17, 1875.

THE insect forming the subject of this sketch belongs to a small and aberrant group of butterflies, which was first brought to the attention of naturalists when Hübner, somewhere between 1806 and 1819, figured in his Sammlung exotischer Schmetterlinge, a Central American species under the name of *Rusticus adolescens Minijas*. Hübner's views of the affinities of the insect were given only by means of his peculiar trinomial nomenclature, but this indicates that he considered its position to be among the Lycænidæ of modern authors. This view was also maintained by him at the publication of the fifth sheet of his Verzeichniss bekannter Schmetterlinge, probably issued in the latter part of 1818,[1] where he places the genus Eumæus, now founded for the species Minijas, at the head of his Agrodiæti, followed immediately by the European blues and preceded by the Oreades, or Satyridæ of modern authors.

It is not a little remarkable that this same insect, under a different specific name, Toxea, should have received, by the next author who treats of it, a new generic appellation closely resembling that given by Hübner. Godart, in the appendix to the Encyclopédie méthodique, calls it Eumenia, and considers its place to be between the Brassolidæ and Satyridæ of modern authors.

Boisduval in his Spécies général next proposes to place this butterfly, with our species and others which had by this time been added to this genus — all Central American and West Indian forms — in a distinct family to which he applies the Gallic term Euménides; and in this he is followed by Doubleday in his List of the British Museum Insects; but the latter author calls the "family" Eumæidæ,[2] and places it between the Erycinidæ and Lycænidæ, while Boisduval places it between the Pieridæ and Lycænidæ. Guerin, in his Iconographie, on the other hand, places the genus among the Erycinidæ of modern authors; and in this he is followed by Lucas in Chenu's Lépidoptères. But most recent authors have returned to the first opinion of Hübner and classed the genus with the Lycænidæ.

This has resulted doubtless from the careful account of the structural features of the insect given by Westwood in the Genera of Diurnal Lepidoptera. Even Boisduval is constrained to take this view in his Lépidoptères de la Guatemala, although he misconceives the affinities of these insects in locating them as he does at the very head of the Lycænidæ, while placing the Pieridæ next above them — an arrangement wholly unnatural. In the system adopted by Westwood they are placed indeed at the head of the Lycænidæ, but the Erycinidæ im-

[1] For a discussion of the probable dates of Hübner's works, see my Historical Sketch of the Generic Names proposed for Butterflies. Proc. Amer. Acad. Arts, Sc., x, 96–8.

[2] This family name is retained also in the plates of the Genera of Diurnal Lepidoptera.

mediately precede them and indicate much more truly the real affinities of the group. Kirby, in his recent catalogue, repeats the error of Boisduval but in a different manner, placing the group at the close of the Lycænidæ and immediately preceding the Pieridæ.

Bates remarks, in the Journal of Entomology, that Eumæus differs from all Lycænidæ in the closure of the cell by perfect nervules and adds in a note that "if the lower discocellular nervule prove to be aborted constantly in the numerous aberrant genera of Lycænidæ of Eastern Asia, the genus Eumæus might form a subfamily of Lycænidæ, founded on the closure of the wing cells."[1] Later, however, in the same Journal,[2] he entirely omits mention of the closure of the wing cells in his characters of the family Lycænidæ and we shall see, further on, that in Eumæus the nervures at the extremity of the cell are not all "perfect."

The whole structure of these insects, whether we notice the high and narrow front of the head, the antennæ inserted in distinct pits, so far separated as to infringe upon the eyes, the form and relation of the parts of the thorax, the shape and neuration of the wings, or the diverse development of the front legs in the two sexes, shows that they belong to the great family of Rurales, including the Vestales or Erycinidæ of modern authors and the Ephori or Lycænidæ of recent times. Their affinity with the Oreades is wholly imaginary, no common bond of union existing between them, other than that borne by all Rurales. What their position within the group may be is, as we have seen above, a matter of very diverse opinion; nearly all those authors who have given proof that they have paid close attention to the structure of the genus agree, however, in placing it among the Ephori, in close proximity to the Vestales. This is undoubtedly its correct general position, although whether it should be classed with the one subfamily or the other, or form a third subfamily, midway between them, will admit of discussion. We will first examine in detail the structural features of the genus.

The body of the perfect insect is somewhat robust, slightly compressed, the abdomen ample, a little compressed and dorsally keeled. The head is of moderate size, thickly covered with erect scales, which are short and form an even nap on the front, longer and massing into irregular oblique tufts on the summit, and into a higher, straight, transverse tuft posteriorly. Eyes of moderate size, not very full, naked, infringed upon by the posteriorly expanding occiput. Antennæ twice as long as the thorax, and less than half as long as the forewings, composed of about thirty-eight joints, slender beyond the basal joints, gradually expanding throughout, but more noticeably a little beyond the middle, to form the club which again tapers at the tip, including the last five or six joints, to a bluntly rounded apex; the scaly covering of the stalk and club is concolorous, and the inner naked surface of the club is provided with a few very short fine bristles on each joint. Labial palpi horizontally extended, very slender, as long as the breadth of the head, clothed with closely appressed scales, the middle joint nearly equal throughout, scarcely curved upward, the apical joint a little more than one third (♂) or nearly one-half (♀) the length of the middle joint, slender, pointed. Tongue as long as the hind tibiæ and tarsi combined.

Wings (Pl. XIV, fig. 14) large, ample, well rounded, entire, alike in form in the two sexes, excepting the little greater fullness of the subcostal portion of the outer margin of the hind wings in the female. Fore wings: costal margin rather strongly arched next the base, be-

[1] Journ. Ent., I, 220.

[2] Journ. Ent., II, 176.

yond nearly straight until toward the tip, where it slopes downward; outer margin gently and almost regularly convex, bending slightly next the lower median nervule; inner margin nearly straight. Costal nervure (fig. 13) terminating at about the middle of the outer two-thirds of the costal margin; subcostal nervure with two superior and two inferior branches, itself striking the tip of the wing; the first superior nervule is thrown off a little beyond the middle of the cell, the second midway between it and the tip of the cell; the first inferior nervule is continuous with the upper margin of the cell, and parts from the main stem either just before (♀, fig. 13) or just beyond (♂, fig. 15) the tip of the cell, without the intervention of any discocellular vein; the lowest subcostal nervule is connected with the main stem by an almost obsolete discocellular vein, which unites with the base of the nervule at an angle of about 130°. The origin of the first and second median nervules corresponds to that of the two superior subcostal nervules; and the nervule closing the cell unites with the apical portion of the median nervule at a right angle.

Hind wings: costal margin very slightly convex beyond the well arched base; outer margin full and pretty regularly rounded; inner margin gently convex, all the angles well rounded. Costal nervure strongly arched at the base, beyond running subparallel to the costal margin which it strikes close to the tip; the subcostal nervules are separated at equal intervals, the nervule uniting the bases of the second and third nearly obsolete excepting above; the median nervules similarly arranged, the nervule closing the cell lying at right angles to apical portion of the median nervule; internal nervule striking the middle of the inner margin.

Fore-tibiæ and tarsi two-thirds (♂, fig. 17) or three-fourths (♀, fig. 16) as long as those of the hind legs, the tarsi consisting either of a single, nearly uniform but tapering, wholly exarticulate joint, a little smaller than the tibiæ, slightly curved downward at the tip, heavily clothed with scales and armed profusely beneath with spines, the apical ones of which are slightly stouter than the others and slightly curved, the apex of the joint abruptly docked, fringed densely with a pile of delicate short hairs representing the paronychia, and supplied above with three or four long curved hairs directed forward (♂); or distinctly five jointed, tapering, the first four joints scarcely smaller than the tip of the tibiæ, the apical joint much smaller; the three middle joints of equal length and together scarcely equalling the the first in length, the last nearly equalling in length the two previous joints; all profusely armed beneath with stout and slender spines, and at tip with still stouter naked spurs, all straight and tapering; the apical joint supplied with apical hairs, claws and well developed paronychia, similar to those of the other legs but smaller, the paronychia slenderer and less heavily fringed (♀). Middle femora with a heavy fringe of scales on its inferior surface growing more prominent away from the base, but at the tip suddenly shortening so that the edge of the scales shows a concave excision; tibiæ and tarsi thickly covered with closely appressed scales, the tarsi with a pair of distant, scarcely divergent, small, compressed, slightly curved, regularly tapering, finely pointed claws; pulvillus small but thick and stout; paronychia broad and rather short, subtriangular, the lower portion the most protuberant, the edge heavily fringed with minute curving hairs.

The abdominal appendages of the male are almost entirely concealed by the terminal segment which so completely encloses them as to leave only a small oval vertical opening, through which protrude the acicular, apically expanded intromittent organ and a pair of pencils of long hairs which have their origin on either side of, and above it; the upper

organ forms a large, semicylindrical, superior shield, broader than long, strongly arched laterally, with a slight median excision and acicular, strongly curved, pointed arms, directed at first inward, forward and downward until they meet, and then suddenly backward. The clasps form a pair of broad, nearly flat, horizontally extended alations destitute of any elevated processes.

From this review of the characters of the perfect insect, the only stage hitherto well known to naturalists, it is evident that Eumæus should be classed with the Ephori; the fore legs of the male are amply provided with spines beneath and even show signs of the paronychia present on the other legs; and the subcostal nervure of the fore wings is furnished with only two superior, and two inferior nervules, (the latter the discoidal nervures of the English entomologists,) while in all Vestales there are at least three superior subcostal nervures.[1]

Its affinities to the Armati (or hairstreaks) are the strongest, both on account of the characteristics of structure in the fore tarsi of the male and the presence of but two superior subcostal nervures to the fore wing, instead of three, as in the Adolescentes (or blues) and Villicantes (or coppers); in the structure of the antennæ it also resembles the Armati more than the other groups; but it differs from all other of our native Ephori in a most striking manner in the obsolescence of the nervule at the base of the terminal subcostal nervule in all the wings; and also in the tapering of the antennæ at the tip of the club, and in the horizontal position of the nearly straight, middle joint of the palpi; so that it evidently must form a group apart from the three with which we have compared it, above and of equal value to each of them; to this group we may apply the name Eumæidæ first given to it by Doubleday, the name Euménides previously applied by Boisduval being excluded from its gallic dress.

The caterpillar and chrysalis of *Eumæus Atala* have recently been obtained by Dr. Palmer and Mr. Maynard, and placed in my hands for examination by my friend Dr. Packard. These will aid us in determining the position of the group. The chrysalis has been described briefly by Westwood,[2] but incorrectly, so that it seems a little doubtful whether he had the proper form before him or not. The egg was also collected by Dr. Palmer, but the specimens were lost; this, however, would have been of less aid than either the larva or chrysalis; for few as have been the descriptions of the larvæ and pupæ of Vestales, but a single egg of one of that subfamily is known; this is that of the European species and is described as being almost globular, smooth and shining, and, therefore, very different from that of the Ephori, which are always echinoid, or semi-echinoid in shape and have their surface studded with numerous and deep pits.

The caterpillars brought home by Dr. Palmer represent the last three stages of this period of *E. Atala*. Of these the final stage differs remarkably from the penultimate and antepenultimate, which, in their turn, resemble each other very closely, and for our present purposes need not be separately described. In these two stages (figs. 3–5) the caterpillar bears very little resemblance to the ordinary type of larvæ among Ephori. It is nearly cylindrical, long and slender, with distinct, even pretty well developed prolegs, a rather large head, only partially retractile within the first thoracic segment, and this segment

[1] Bates mentions an exception in the genus Isapis, in which no nervure at all is emitted before the end of the cell.

[2] Genera Diurn. Lepidoptera, 469–470.

scarcely larger than the succeeding; the terminal segments are distinct and uniform in size as in caterpillars of other families, the terminal segments not depressed, and the spiracles of the eighth abdominal segment on a line with the others. All the spiracles, however, are situated high up upon the body as in the other members of this sub-family, so that the lateral row of fleshy, thorn-bearing tubercles, which, in most other caterpillars, would be supra-stigmatal, or situated even relatively higher on the sides, are here ventro-stigmatal; and the upper similar series, which, like that previously mentioned, extends along the whole length of the body, is pleural when it appears to be pleuro-dorsal (fig. 4); each of these rounded elevations bears a number of pretty long, slender, tapering thorns, and the whole body is covered with minuter ones; the posterior segment is fringed with a bristling mass of thorns similar to those on the tubercles, and the first thoracic segment where it is thickened above the head, is similarly though not so heavily armed. The head is smooth, well rounded and compact, about two-thirds the width of the first thoracic segment. The legs are small and bear a very delicate claw. The prolegs are provided with a double interior series of about fourteen hooked spines each, alternately long and short; the anal prolegs are particularly well developed, being scarcely shorter than in the Papilionides.

In the characteristics of the caterpillar at this stage therefore, Eumæus departs widely from the ordinary type of Ephori, whose caterpillars are decidedly onisciform with excessively short though perfectly developed legs and prolegs, a minute head wholly retractile within the greatly developed first thoracic segment, the terminal segments more or less coalesced and the spiracles of the eighth abdominal segment situated above the line upon which the others are ranged. When, however, we come to the final stage of Eumæus (figs. 6–9), we find the thoracic segment slightly enlarged, tumid and overhanging the head (figs. 6, 9), the whole ventral portion of the body flattened, and the dorsal portion arched, with ridges running along pleural and ventro-stigmatal lines accentuated by the fleshy tubercles still situated there, the terminal segments coalesced to a slight degree, and flattened so as to bear a close resemblance to those of the lower Ephori. The spiracles, however, are still in a straight line, and although the segments are transversely ridged on their posterior border, apparently by a contraction of the mass in this quarter (fig. 7), the animal is still of unusual length and slenderness for one of this family. So, too, the head is still only partially retractile within the first thoracic segment, and the anal prolegs are pretty well developed.

These characteristics wherein the larva of Eumæus differs from the generality of Ephori are the very ones wherein it is allied to the Vestales, and shows the correctness of Westwood's arrangement of the genus and of the conclusions to which we have already arrived. Very few larvæ of Vestales are known, and those with which we are acquainted differ considerably among themselves; they are, however, not always so strikingly onisciform as are the Ephori and are sometimes furnished with tufts of short hairs or lateral fleshy appendages, and even, on the first thoracic segment, with long spines; the first segment of the body is not enormously developed, nor, apparently, is the head retractile, at least to the extent that it is in the Ephori. The larva of *Ancyluris Melibœus* is described as furnished with tubercles or solid points of unequal length placed in two rows on either side of the body; and as, in general, resembling the caterpillar of Liparis. It would seem to be not unlike that of the penultimate stages of Eumæus.

Eumæus therefore, judging from the larva, is one of the Ephori which approaches the

Vestales most closely, but is so different from the lower tribes of the sub-family, that were we to base our opinion on the caterpillar alone we could hardly help considering the Eumæidæ as a group possessing a value equivalent to the rest of the Ephori. This view, however, we shall be unable to maintain after an examination of the other stages of the insect.

The chrysalis (figs. 10–12) is stout, full, arched and rounded, the mesothorax elevated, domed and mesially subcarinate,[1] separated by a pretty deep excision from the very full and arched abdomen, which is much higher than the thorax and rather abruptly elevated at the second segment. The head is small, not at all protuberant, situated entirely upon the under surface of the body, so as not to be seen on a dorsal view, being concealed by the fullness of the prothorax; this is very broad, somewhat tumid, especially laterally, closely resembling the same part of the larva at its final stage; the under wings are entirely concealed by the upper. The body, viewed from above, is obovate, very obtuse at either end, but especially in front, broadest from the second to the fourth abdominal segments, the under surface not flattened but broadly rounded transversely, the terminal segment of the abdomen apical though directed downward, and the cremaster reduced to some slight rugosities, wholly destitute of armature. The body is girt by silken threads which pass between the first and second abdominal segments dorsally, and then are directed forward (fig. 10); it cannot be attached at the posterior extremity of the body, as stated by Westwood, for absolute want of any hooks to plunge into the silk.

In the Vestales, as far as one can gather from the few meagre descriptions and imperfect illustrations that are published of their transformations, the head of the chrysalis is visible from above, as in all chrysalids of butterflies, excepting those of Ephori, and the chrysalids themselves are often angulated. In the Ephori, on the other hand, the head is always upon the under surface of the body, concealed from view on a dorsal aspect, and so, also, to a greater or less extent, is the last segment. The chrysalids are always rounded and entire. There can be no doubt, therefore, that the affinities of Eumæus at this stage are decidedly with the Ephori, although the terminal segment of the body seems to be more exposed dorsally than is usually the case with them. It evidently resembles that of the Armati more closely than it does the other tribes of Ephori, but has a more flattened and laterally expanded prothorax.

The different tribes of Ephori differ from each other in the chrysalis state in a curious manner and one which has never yet been noticed. The dermal appendages of Armati, for instance, consist of equal hairs, tapering only at the tip, profusely provided with minute spicules diverging from the stem at but a slight angle. The dermal appendages of Adolescentes consist of uniformly tapering hairs, abundantly provided with minute spicules, which diverge from the hairs at right angles. Those of the Villicantes are fungiform. The Eumæidæ, again, are provided with compressed, ribbon-like hairs, equal, tapering only at the extreme tip and slightly twisted throughout their length. In this respect again Eumæus is most nearly allied to the Armati.

A few years ago in my Systematic Revision of North American Butterflies I indicated my adhesion to the views of a few writers who considered the two groups, known in modern times as Erycinidæ and Lycænidæ, but to which the earlier terms Vestales and Ephori should be applied, as but a single family. New and unlooked for evidence in this direc-

[1] It cannot be correctly described, as Westwood has done, as "raised into a slight conical protuberance."

tion is derived from the structure of the Eumæidæ, which, while they must be classed with the latter of the two groups, give strong evidence of their affinities to the former. The onisciform or sub-onisciform character of the larvæ in these two large groups, their retractile or semi-retractile heads, the compact form of the chrysalids and their closely girt attachment to their support, together with the opposite development of the forelegs in the two sexes of the imago and the close similarity of all other points in the structure of the perfect form show that no family distinction can be drawn between the two groups; while the characters they have in common are very many of them in striking contrast to those found in any other family of butterflies. It is perhaps in the larvæ that the two groups show the greatest distinction from each other, and this distinction is bridged over by the aberrant tribe of Eumæidæ, leading us to suppose that were the transformations of other allied forms known, we should find many more points of similarity than at present.

Eumæus Atala is an exceedingly common insect in Cuba, and is found in great abundance on the Florida Keys and the southern portion of the peninsula itself. Mr. C. J. Maynard, who has travelled extensively over that portion of Florida, tells me that it hardly occurs north of Miami on the east coast, although the food-plant of the larva extends north as far as Smyrna.

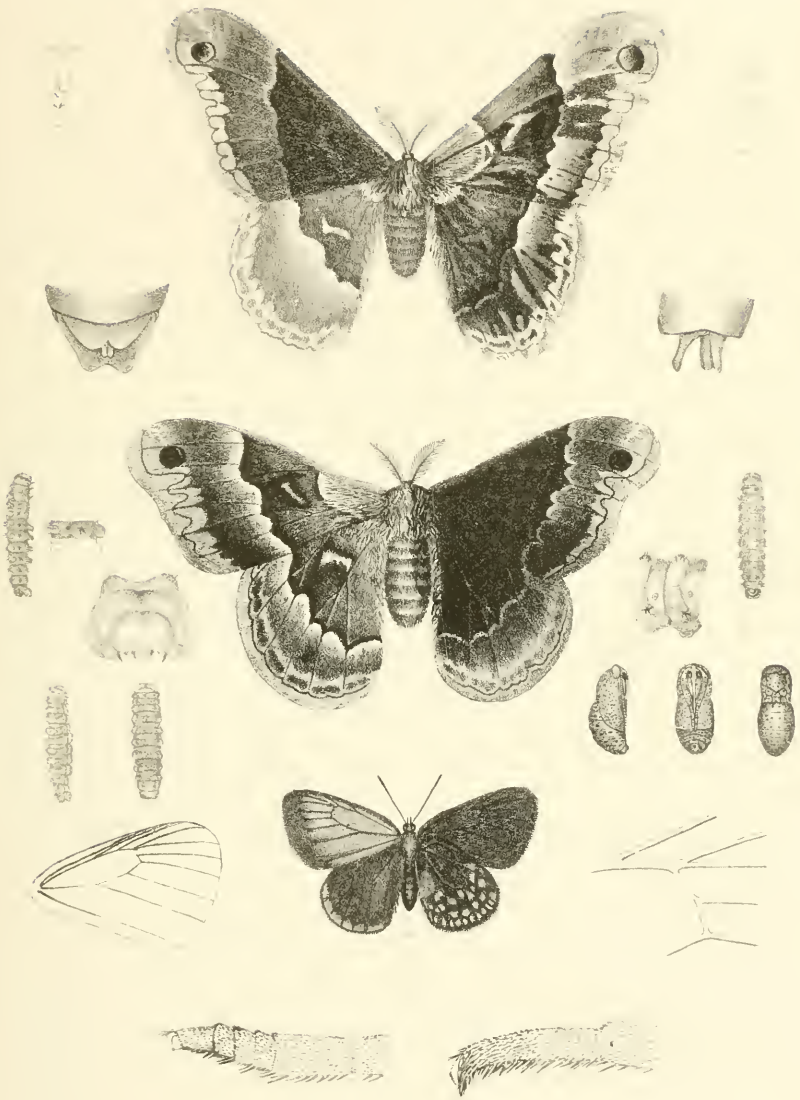
In Florida the butterfly emerges from the chrysalis early in January and is abundant throughout this month. I found it also abundant in Cuba late in February or early as March and took specimens at that time emerging from the chrysalis. Dr. Palmer saw the butterfly laying her eggs at Biscayne Key in July, and during this month caterpillars of every stage were found. The caterpillar feeds upon both surfaces of the leaves of *Zamia integrifolia*, but seems to prefer the upper surface. The chrysalis is usually attached to the under surface of the leaves or to the stem of the same plant, but sometimes to other plants and even to grass, the head uppermost.

Explanation of Plate xiv.

(Figs. 1 and 2 belong to the preceding memoir.)

Fig. 3. Penultimate stage of caterpillar; side view.
Fig. 4. The same; side view of one of the abdominal segments, enlarged.
Fig. 5. The same; dorsal view.
Fig. 6. Final stage of caterpillar; front view of head and first two thoracic segments, enlarged, showing the tumescence of the first thoracic segment and the ventral expansion of the caterpillar at this stage, in contradistinction to its cylindrical form in the previous stages; the latter feature is less conspicuous on the plate than in nature.
Fig. 7. The same; side view of parts of three abdominal segments, enlarged.
Fig. 8. The same; side view; the artist has given much too cylindrical an appearance to the caterpillar.
Fig. 9. The same; dorsal view, the head concealed by the overhanging first thoracic segment.
Fig. 10. Chrysalis; side view with attachment.
Fig. 11. The same; ventral aspect.
Fig. 12. The same; dorsal aspect.
Fig. 13. Imago; neuration of fore wing of female, enlarged.
Fig. 14. The same; male; the left side shows the upper, the right the under surface.
Fig. 15. The same; neuration of extremity of cell of fore wing in the female, enlarged.
Fig. 16. The same; fore tarsi and part of tibia of female, enlarged.
Fig. 17. The same; fore tarsi and part of tibia of male, enlarged.

N. B. — The drawings of the earlier stages were all taken from specimens preserved in alcohol. Figs. 13, 15, 16, 17 were drawn by S. H. Scudder; the remainder by S. E. Cassino.



XVI. Prodrome of a Monograph of the Tabanidæ of the United States. Part II. The Genus Tabanus. By C. R. Osten Sacken.

Read November 17, 1875.

TABANUS.

The total number of the hitherto described species of Tabanus from North America, north of Mexico, is one hundred and two. Of these descriptions thirty-four have been identified, and the names connected with them adopted in the present paper. Twenty-six other species, although identified, have been recognized as synonymous with previously described ones; and thus forty-two names remain as yet to be disposed of. It is very probable that among these forty-two names a very small number (perhaps not more than three or four) represent species really unknown to me; the large majority are either recognized as doubtful synonyms of some of the identified species, or else they are unrecognizable, on account of the insufficiency of the descriptions.

Twenty species I describe as new; not that I am convinced that none of them have ever been described before, but because I could not recognize them with any reasonable degree of probability among the forty-two unidentified species. The total number of species of Tabanus from North America, north of Mexico, described in the present paper, is thus brought to fifty-four.

The task of the critic, as far as descriptions go, being nearly completed, the comparative merit of the work of the different writers is brought out in a very striking light. Of Wiedemann's more than twenty species (including those of Fabricius, which we know only through Wiedemann), all but three are identified; and of these three one is very probably a species I do not know (*T. gracilis*); the second (*T. nigripes*) is as good as identified, and the name is not adopted merely because another name, by Macquart, was preferred; the third is a very doubtful Fabrician species, belonging to a difficult group and described by Wiedemann from a very imperfect specimen in Fabricius's collection (*T. marginalis*).

As long as my materials were limited, the identification of several of Wiedemann's descriptions remained doubtful; when, among closely resembling species, I did not possess the right one, I was sometimes led to identify a wrong one. But with the increase of material these difficulties vanished, and even among closely allied species the right one was recognized, thus showing the faithfulness of Wiedemann's work.

Of Mr. Walker's twenty-nine species nineteen are unrecognizable to me, seven are synonyms of other, mostly well known species, and only three are adopted. Among these three I am not very sure whether *T. catenatus* Walk. should not be better called *T. rece-*

dens Walk.; *T. fulvescens* may be only a variety of *T. bicolor* Wied.; and if I recognized *T. trijunctus*, it is principally because I remembered having seen it in the British Museum.

Macquart's descriptions, although short, are more to the point than the unmeaning descriptions of Mr. Walker. But Macquart at different times worked in different entomological cabinets, without comparing, or remembering, his former types; thus he came often to describe his own species again. Besides, he generally took but little trouble about identifying the descriptions of previous authors. Among the twenty-three species described by him six are adopted, five are synonyms, and twelve are among the unrecognized and doubtful.[1]

In adopting the species of former authors I have tried to hold the middle course between too much confidence and too much skepticism. The latter is as injurious as the former, as it leads to a new increase of synonymy. With the comparatively large material which I had, besides the literal interpretation of the descriptions, a process of exclusion comes into play, which reveals probabilities almost amounting to certainties. A description is referred to a certain species, not because they exactly agree, but because no other species from the same region is known that agrees better.

During my journey to Europe, in 1859, I had an opportunity of seeing the Museums of London and Paris, and to take a few notes, some of which I could turn to account now. Unfortunately, my knowledge of North American Tabanidæ at that time was very limited, and thus the usefulness of a flying visit to those Museums was diminished in proportion. About some of Wiedemann's types in the Vienna Museum I took the liberty of addressing a few questions to Dr. Redtenbacher, the Director of that Museum. His kind answers fully confirmed the surmises I had already formed from Wiedemann's own descriptions, about the identity of two or three doubtful species.

By such means I hope, in the great majority of cases, to have avoided the two evils of misapplying old names, or of unnecessarily introducing new ones. But should I even have been occasionally mistaken, the evil is lessened by my having given full descriptions of all the species, whether old or new.

In describing, my only aim has been to enable others to recognize the object described. Tabani are variable in life; they are still more variable in collections, according to the degree of preservation of the specimens. I have purposely omitted statements which seemed unnecessary for the practical aim I had in view, and I have purposely used vague expressions, where any positive statement would have been misleading. I am far from flattering myself that in every single case my descriptions will be recognized, but I believe that the possessor of a reasonable amount of material will be able to identify most of the species with much less trouble now than before the publication of my paper. In the difficult groups of *T. abdominalis, tectus, variegatus*, of *T. longus*, or of *T. socius, septentrionalis, illotus*, — groups containing either very variable species, or several closely resembling

[1] Summary of the critical review of N. A. species (north of Mexico) described by former authors: —

Identified and adopted . . . . . 34 species.
(1 Linné, 1 Förster, 1 DeGeer, 5 Fabricius, 3 Palisot, 9 Wiedemann, 2 Say, 6 Macquart, 2 Kirby, 3 Walker, 1 Loew).

Identified and given in the synonymy . . . . 26 species.
(1 DeGeer, 2 Drury, 4 Fabricius, 1 Palisot, 1 Meigen, 2 Wiedemann, 5 Macquart and 7 Walker).

Unknown, doubtful, unrecognized or unrecognizable . . . . . 42 species.
(2 Linné, 1 Fabricius, 2 Wiedemann, 1 Palisot, 1 Say, 12 Macquart, 1 Rondani, 19 Walker).

Total . . . . 102 species.

ones, I have described what I considered as well-defined types, indicating at the same time the aberrant types, but without deciding whether they are species or varieties. The discrimination of closely allied species in such cases, is a matter of time and of local observation.

One of the difficulties one has to contend with in describing species of Tabanus, is the small number of males usually found in collections, and the uncertainty, in some cases prevailing, as to what species they really belong. Among the twelve species of the subgenus Therioplectes I have not seen the males of more than one half, although the females were numerously represented. It would be imprudent to attempt the description of the probably numerous closely allied species of that group, without the knowledge of both sexes. Males are usually the bearers of the most distinctive and most plastic characters, and in the present genus, owing to their scarcity, they do not seem to have been sufficiently studied. A great deal remains to be learned yet from local observation on males and females caught in the same locality. Thus Dr. Zeller, in 1842, separated from the common European *T. bovinus* the closely allied *T. sudeticus*, which, in the female sex, shows but slight differences, while in the males a most marked distinguishing character exists: *T. bovinus* has the facets nearly of the same size over the whole eye, while *T. sudeticus* has the usual dividing line between large and small facets very distinctly drawn.

It will be noticed that the descriptions are not preceded by diagnoses of the species. I thought that a carefully prepared analytical table, as well as the comparisons of closely allied species, which I have placed at the end of the descriptions, sufficiently supply the place of diagnoses.

The most trustworthy characters[1] for the discrimination and description of the species of Tabanus, are the plastic characters taken from different parts of the head: the shape of the palpi, of the third antennal joint, of the frontal callosity and the breadth of the front itself; in the male, the shape of the head, and the relative size and distribution of the large and small facets on the eyes. Although not absolutely immutable, these characters are more so than coloring or pubescence; they have, moreover, the advantage of greater durability, and can be observed even in badly preserved and old specimens. Some of these characters, of course, do not admit of any other but of a comparative description; thus when I say "front rather broad," I suppose the reader to be acquainted with the frontal breadth in the allied species. The venation of the wings affords very few available characters; the most useful is the degree of opening of the first posterior cell at its distal end. The differences in the markings on the eyes have been used for the discrimination of certain closely allied European species. These markings are not absolutely the same in all specimens of the same species, and Zeller observes in this connection that the *position* of the crossbands is of more importance than their length or breadth. Slightly marked crossbands, with an indefinite outline, are apt to disappear altogether in some specimens (see Loew, l. c., p. 575).

The coloration of the eyes can usually be revived in dry specimens by putting them on moistened sand for a few hours. The experiment, however, does not always succeed, and

[1] To those who wish to know more about the characters available for describing species of Tabanus, I recommend Dr. Loew's Zur Kenntniss der Europaischen Tabanus-Arten (Verh. Zool. Bot. Ges., Wien, 1858, p 573–612) and Zeller's article in Oken's Isis, 1842.

often spoils the specimens (and this circumstance, in many instances where I had but a few specimens of a species, has prevented me from ascertaining the coloring of their eyes).

The coloring of the antennæ, from red to brown and black, is, in most cases, characteristic, but cannot be relied upon in every single specimen; when, for instance, the attenuated portion of the third joint, before the annulate portion, is infuscated, the extent of the brown is apt to be very variable; the two basal joints also often vary from reddish to dark brown or black in different species. The same may be said of the extent of the dark color on pale colored legs; even the femora undergo, in some cases, the most unexpected variations. Besides, the bristles and hairs covering the legs often assume different hues, according to the direction of the light falling in upon them.

The pollinose, or denuded condition of the *subcallus* (the part of the front between the callosity and the root of the antennæ) is, according to Loew, not an altogether trustworthy character, as, in some European species, for instance, *T. luridus*, it occurs adventitiously; while in others it is of a pretty constant occurrence. In the American *T. lasiophthalmus* and *rhombicus* I always found the subcallus denuded.

The coloration of the eyes of Tabani consists of crossbands, usually green (or bluish) on purplish ground, or purplish on green ground; sometimes all but one crossband disappear; occasionally the whole eye is unicolorous. I have no doubt that a more attentive study of the coloration would, in some cases, supply useful hints as to the distribution of the species in groups. The following instances of coloration have partly been seen on the living insect, partly on alcoholic specimens; in many cases the eyes have been artificially revived.

1. *T. turbidus*, *trijunctus*, *catenatus*, *abdominalis* (var.), *tener*, *tectus*, *variegatus* (probably also *T. fronto*), have their eyes colored on the same pattern, that is, there are two subparallel green bands on a purple ground, the lower one, before its outer end, bending towards the upper one. *T. molestus* and *trimaculatus* show nearly the same pattern, only the crossbands are more narrow, more parallel, and with a broader interval. All these species seem to form one natural group.

2. *T. fuscopunctatus* differs from all these species in having but a single narrow purple stripe on green ground, the lower portion of the eye being again purple.

3. *T. psammophilus* has, on blue ground, two broad green stripes, the broad interval between which contains a third much narrower green stripe.

4. *T. costulis* and *nigrovittatus* have light green eyes, with a single narrow purple crossband. *T. fulvulus* and *sagax*, evidently related to them, have besides this single crossband in the middle, two others, one above and one below, but less distinctly marked.

5. The eyes of *T. lineola* have a pattern somewhat akin to the preceding, but decidedly original. The eye is green, with a purple central band, and another above it, which is abruptly interrupted about the middle of the eye; the whole upper, outer and lower orbits of the eye have a dark purple border.

6. *T. nigrescens* and *stygius* have dark colored, greenish eyes, with a central, rather dark purplish crossband, and usually less distinct bands above and below; the bands are not half as broad as their intervals.

7. The Tabani with unicolorous eyes belong to several distinct groups: —

a. *T. melanocerus* and *nigricornis*.

b. *T. Orion* and *Actæon* seem also to have unicolorous eyes, at least I have not been able to revive the colors by moisture.

c. *T. americanus* has uniformly green eyes; those of *T. giganteus* are also unicolorous.

8. *T. Reinwardtii* has two bluish green stripes, with a rather broad interval, the lower one bent towards the upper one at the outer end, without reaching it; thus, its pubescent eyes notwithstanding, it resembles in this respect the Tabani of the first group.

9. *T. cerastes* has a single blue crossband across the middle of the eye.

10. The whole subgenus *Therioplectes* has three or four green or bluish green crossbands on purple ground (*T. zonalis* and *cinctus* have four dull green bands, *T. trispilus* four bright ones, etc.).

These instances plainly show the connection which exists between the coloring of the eye and the relationship of the species; but they show at the same time the great variety of types which exist within the genus Tabanus.

The subdivision of the genus Tabanus into smaller genera, natural groups or subgenera, lies beyond the scope of the present paper. In order to be carried out successfully, such an attempt would require the study of the species from all parts of the world. Tabanus, on the whole, is a remarkably compact genus, but with a great variety of specific types. The wiser course, perhaps, will be to treat the subdivisions as subgenera only, providing them, however, with separate names, as has been done in the genus Trypeta. I will confine myself here to a few remarks about the subgenus Therioplectes, proposed by Dr. Zeller in 1842 for the Tabani with pubescent eyes. The subgenus thus defined contains some heterogeneous elements in Europe (*T. rusticus* and *fulvus*), and still more so in North America. We improve the definition of this group, however, through the use of a character which has been hitherto neglected, but which seems to be a character of higher order, that is, more indicative of a natural relationship than the pubescence of the eyes; I mean the presence of a more or less distinct ocelligerous tubercle on the vertex. Often a rudimentary ocellus is perceptible upon the tubercle; sometimes quite distinctly (for instance, in *T. cinctus*, as was already noticed by Meigen). This character, more distinct in the female, is often also visible in the male. The ocelli seem to be rudimentary, and should not prevent the absence of ocelli from being quoted among the characters of the genus. The new definition, as far as applicable to the American species, would run thus:

Therioplectes. Eyes pubescent; ocelligerous tubercle more or less distinct; eyes (♀) with three or four bright green or bluish crossbands; head of male not differing much in size and shape from that of the female; the difference in size between the large and small facets upon it is but very moderate, and hence the line dividing them rather indistinct (especially in dry specimens).

Thus limited, Therioplectes forms a rather homogeneous group of twelve American species (Nos. 43–54). The two species *T. bicolor* and *fulvescens*, as well as their relatives, the European *T. fulvus* and *rusticus*, would be excluded from it and form a separate group, which I propose to call Atylotus, and which may be characterized as follows: —

Atylotus.[1] Eyes pubescent, no vestige of an ocellar tubercle; frontal callosity wanting in the two American species (or small and rudimentary, in the European species); head rather large, very convex anteriorly, and rather concave posteriorly; difference in size between the large and small facets in the male considerable, line of division between them very distinct (even in dry specimens); palpi (♀) stout at base; upper branch of the third longitudinal vein knee-shaped at base (emitting a stump of a vein in the European species); first posterior cell broadly open; coloration of the eyes uniform (sometimes a single indistinct stripe). The coloring of the eyes I quote after European authors; I do not know that of the American species, but have little doubt, from the appearance of the dry specimens, that it is the same as in the others.

The next relative of Atylotus in North America would be *T. mexicanus*, which is very nearly an Atylotus with glabrous eyes. And again the group of *T. costalis. nigro-vittatus*, *fulvulus*, *sagax*, with their stout palpi, broadly open first posterior cell, green eyes, somewhat knee-shaped basis of the upper branch of the third longitudinal vein, etc., seems likewise to be related to Atylotus.

Of the total number of North American Tabani described by me, only two (*T. punctifer* and *T. rhombicus*) belong to the region beyond the western plains, and therefore fifty-two inhabit the region east of the plains, that is, the valley of the Mississippi, the Atlantic States and the British Possessions. The fauna of this region, especially of the Southern States, is far from being exhausted, and the number of species will certainly reach far beyond sixty. At present I know already about half a dozen species, which I have seen in collections and have not introduced in this paper, not wishing to describe new species in this difficult genus from single specimens, except in cases where a species is as striking as *T. cymatophorus*, and where the specimen was uncommonly well preserved. Twenty-four species I know to occur in the New England States alone, and even this number will undoubtedly be increased. For comparison's sake I will state that Zetterstedt has twenty-four species for Sweden, Norway, Denmark and Finland; Schiner thirty-two for Germany and Austria; Zeller thirteen for Silesia. As yet not a single species of Tabanus common to Europe and North America has been ascertained to exist, although some of the northern species of the group Therioplectes come very near to European species (for instance, my *T. socius* to *T. tropicus*). It is not improbable that with a better knowledge of that group some cases of undoubted identity will be disclosed.

All the original specimens of my descriptions, as well as all the varieties and aberrant specimens mentioned in my text, are to be found at the Museum of Comparative Zoology, in Cambridge, Mass. The most important contributions from abroad I received from the Entomological Society in Philadelphia, and from the Detroit Scientific Association[2]; for both of which I return my sincere thanks.

OBSERVATIONS ABOUT THE ANALYTICAL TABLE OF THE SPECIES.

1. As the pubescence of the eyes, in female specimens especially, is sometimes very difficult to perceive, either being naturally scarce, or worn off, I have introduced the ocelligerous tubercle as an auxiliary character. I know of no North American Tabanus with a distinct ocelligerous tubercle and, at the same time, with glabrous eyes in both sexes; so

[1] Ἄτυλος, without callosity.

[2] Diptera collected in Florida, by Messrs. Hubbard and Schwarz.

that, whenever a species possesses that tubercle, it must be looked for among those with pubescent eyes, even when the pubescence is not apparent. Hitherto I have found only four North American species which have pubescent eyes and *no ocelligerous tubercle*. Two of them (*T. bicolor* and *f. lvescens*) at the same time have no frontal callosity, and for this reason cannot be easily mistaken. The two others are *T. Reinwardtii* and *T. cerastes*, and for both a double reference has been introduced, so that the right names will be found, even if the pubescence of the eyes should be overlooked. The same precaution of a double reference will be found for *T. rhombicus*, whose ocellar tubercle is indistinct.

2. Of *T. Megerlei* I have a single damaged specimen; I place this species hypothetically among those with glabrous eyes, and, consequently, without ocellar tubercle.

3. The table has been constructed principally for female specimens. Male specimens also can be determined by it, but with a certain caution, as the abdominal markings, which were used a great deal for the discrimination of the species, are generally less well defined in that sex than in the females.

4. I need hardly add that the table will be found useful for determining normally colored and tolerably well preserved specimens, and not for very aberrant or ill-used ones.

ANALYTICAL TABLE OF THE SPECIES.

1. Eyes glabrous; ocelligerous tubercle absent . . . . . 2.
   Eyes pubescent; ocelligerous tubercle absent . . . . . 38.
   Eyes pubescent; ocelligerous tubercle present (subgenus *Therioplectes*) . . . . . 41.

2. Abdomen with definite white markings[1] (altogether white in No. 18) . . . . . 3.
   Abdomen without any definite white markings . . . . . 28.

3. The white markings of the abdomen consist in a single longitudinal row of white triangles. . . 4.
   The white markings, etc., consist of two or three rows of white triangles or spots . . . . . 16.
   The white markings, etc., consist in a distinct white or yellowish longitudinal stripe, running from the scutellum to the end of the sixth segment . . . . . 24.

4. Wings distinctly spotted or clouded with brown (spots sometimes faint only in No. 5); antennæ uniformly red . . . . . 5.
   Wings distinctly spotted or clouded with brown; third antennal joint red, but its attenuated portion black or brown . . . . . 9.
   Wings with more or less faint clouds on the crossveins and the bifurcation of third vein; prevailing color of the antennæ black or brown. . . . . 11.
   Wings without any vestiges of clouds on the crossveins and on the bifurcation of the third vein . 13.

5. Longitudinal veins of the wings broadly clouded with brown; frontal callous much longer than broad, brownish red; first posterior cell broadly open . . . . . **1. turbidus** Wied.
   Crossveins and bifurcation of the third vein alone clouded with brown . . . . . 6.

6. Prevailing color of the front femora dark brown . . . . . 7.
   Front femora altogether red . . . . . 8.

7. Front tibiæ brown at tip. . . . . **2. fronto** n. sp.
   Front tibiæ altogether red . . . . . **3. triligatus** Walk.

8. Brown spots on wings large and conspicuous; third antennal joint almost crescent-shaped, its upper angle being drawn out in a long point . . . . . **4. fuscopunctatus** Macq.
   Brown spots on wings but little conspicuous; third antennal joint not crescent-shaped; abdomen coarctate posteriorly; abdominal triangles long and narrow . . . . . **5. catenatus** Walk.

[1] I call *definite markings* the triangular spots, or oblique lateral spots, or the dorsal line, which occur in some species, and *not* the whitish or yellow coloring of the hind or lateral margins of the segments.

9. Wings tinged with brownish, but without distinct brownish border posteriorly . . . . . 10.
Wings whitish in the middle, with a brownish border along the hind margin; thorax gray, abdomen reddish . . . . . **8. variegatus** Fab.

10. Head (♂) subhemispherical; prevailing color of the thorax (♂, ♀) grayish-black; of the abdomen (♀) brownish red with white triangles . . . . . **6. abdominalis** Fab.
Head (♂) but little different from that of the female; prevailing color of the thorax (♂, ♀) brownish gray or grayish brown; abdomen yellowish brown with white triangles. . . . **7. tectus** n. sp.

11. Abdomen black, with very distinct white triangles . . . . . 12.
Abdomen reddish, with very faint white triangles. . . . . **11. tener** n. sp.

12. A white triangle on second abdominal segment . . . . . **9. molestus** Say.
No white triangle on second abdominal segment; venter with a broad brown longitudinal stripe. . . . . **10. trimaculatus** Palisot.

13. Antennæ black, third joint sometimes reddish at base; abdomen on each segment, with a distinct border of gray pollen, expanding into a triangle in the middle . . . . . 14.
Antennæ reddish, third joint more or less dark towards the end; abdomen with triangles which are not the expansion of a border of gray pollen . . . . . 15.

14. First posterior cell distinctly coaretate; prevailing color of the tibiæ whitish **12. melanocerus** Wied.
First posterior cell not coaretate; prevailing color of the tibiæ black . . . **13. coffeatus** Macq.

15. Front tibiæ almost uniformly colored . . . . . **14. Orion** n. sp.
Distal half of the front tibiæ distinctly darker than the proximal . . . . . **15. Actæon** n. sp.

16. Wings with distinct black spots or clouds . . . . . 17.
Wings without black spots or clouds . . . . . 19.

17. Brown spots only on crossveins and on the bifurcation of third vein . . . . . 18.
The brown spots extend far beyond the crossveins, and give the wing a variegated appearance. . **17. venustus** n. sp.

18. The white triangles in the middle of the abdominal segments coalesce with the lateral oblique spots, the segments being broadly margined with white posteriorly . . . . **16. cymatophorus** n. sp.
The white triangles, etc., do not coalesce with the lateral oblique spots (see No. 41, *T. Reinwardtii.*)

19. Abdomen uniformly white; a distinct stump of a vein on the anterior branch of the fork of the third vein . . . . . **18. psammophilus** n. sp.
Abdomen with white triangles and white lateral spots on the segments . . . . . 20.

20. The lateral spots on the abdominal segments touch the hind margin of the segments[1] . . . . 21.
The lateral spots, etc., do *not* touch, etc. . . . . 23.

21. Upper angle of the third antennal joint drawn out in a long joint (see No. 42, *T. cerastes*).
Upper angle, etc., *not* drawn out in a long point . . . . . 22.

22. Prevailing color of the abdomen white. . . . . **19. nivosus** n. sp.
Prevailing color of the abdomen black . . . . . **20. vivax** n. sp.

23. Middle sized, elongated species . . . . . **21. longus** n. sp.
Small species, third antennal joint remarkably broad . . . . . **22. pumilus** Macq.

24. On each side of the median abdominal stripe there is a lateral stripe (composed of coalescent spots; sometimes indistinct) . . . . . 25.
On each side, etc., there is a longitudinal row of yellowish or whitish, not coalescent, spots . . . 27.

25. Costal cell hyaline; front (♀) distinctly convergent anteriorly . . . . . **23. lineola** Fab.
Costal cell yellowish . . . . . 26.

26. Face whitish; thorax gray, hind tibiæ faintly brownish at tip . . . . **24. nigrovittatus** Macq.
Face yellowish; thorax grayish yellow; hind tibiæ distinctly black at tip . . . **26. costalis** Wied.

[1] In order to obtain a good view of this character, raise the specimen to about the level of your eye, with the tail end towards you; pay especial attention to segments three, four, etc., as on the second segment, the spots are sometimes very nearly contiguous with the hind margin.

27. Lateral abdominal spots yellowish; front narrow; upper angle of third antennal joint prominent; femora usually dark. . . . . **26. fulvulus** Wied.
Lateral abdominal spots whitish; front broad; upper angle of third antennal joint very shallow; femora reddish . . . . . **27. sagax** n. sp.

28. A distinct frontal callosity present . . . . . 29.
No frontal callosity . . . . . **38. mexicanus** Linn.

29. Both abdomen and palpi black . . . . . 30.
Either abdomen or palpi not black . . . . . 35.

30. Prevailing color of thorax and wings not black . . . . . 31.
Prevailing color of the whole body black . . . . . 33.

31. Thorax dark brown above; wings subhyaline, with brown clouds on crossveins. **28. nigrescens** Palisot.
Thorax densely clothed with white pollen or down . . . . . 32.

32. Front tibiæ white at base. . . . . **29. punctifer** n. sp.
Front tibiæ not white at base . . . . . **30. stygius** Say.

33. Front unusually broad, callosity transverse. . . . . **31. atratus** Fab.
Front not unusually broad, callosity not transverse . . . . . 34.

34. Narrow portion of the third antennal joint not remarkably elongate . . **32. Wiedemanni** n. sp.
Narrow portion, etc., remarkably elongate . . . . . **33. lugubris** Macq.

35. Abdomen broadly red on the sides, black in the middle . . . . . 36.
Abdomen black or brown. . . . . 37.

36. Legs and palpi pale reddish . . . . . **34. rufus** Palisot.
Legs and palpi dark . . . . . **35. Megerlei** Wied.

37. Wings hyaline, with a dark brown costal cell . . . . . **36. americanus** Förster.
Wings uniformly brownish yellow . . . . . **37. giganteus** DeGeer.

38. Abdomen without white spots; front (♀) without callosity . . . . . 39.
Abdomen with three rows of white spots; frontal callosity distinct. . . . . 40.

39. Pectus and pleuræ yellowish . . . . . **39. bicolor** Wied.
Pectus and pleuræ gray . . . . . **40. fulvescens** Walk.

40. Gray; third antennal joint not very deeply excised[1] . . . . . **41. Reinwardtii** Wied.
Light chocolate brown; third antennal joint deeply excised, almost crescent-shaped **42. cerastes** n. sp.

41. Prevailing color of the body pure black or brown. . . . . 42.
Prevailing color of the body grayish black or blackish gray; sides of the abdomen often reddish (large group of northern species). . . . . 45.

42. Abdomen with conspicuous yellow crossbands. . . . . 43.
Abdomen without yellow crossbands . . . . . 44.

43. Ante-alar tubercle black; the yellow abdominal crossbands consist of a narrow fringe of pale yellow hair . . . . . **43. flavipes** Wied.
Ante-alar tubercle reddish; yellow crossbands broad, formed by yellow hair on a broad border of yellowish pollen . . . . . **44. zonalis** Kirby.

44. Three first abdominal segments bright orange red, the rest black . . . . . **45. cinctus** Fabr.
Abdomen with a white triangle on each of the segments two, three, four; body of male brownish black; of female grayish black (dark slate color) . . . . . **46. trispilus** Wied.

45. Abdomen with a conspicuous row of white triangles in the middle of the segments, but without lateral white spots (see No. 46, *trispilus* Wied., female).
Abdomen rufous on the sides, this color leaving only a narrow black stripe of the first three or four segments. . . . . 46.
Abdomen on each side with a conspicuous row of white or whitish spots; the rufous color less apparent, or not existing. . . . . 48.

[1] If the species to be determined is from the far west (Colorado Mountains, etc.), compare at this place *T. rhombicus* (No. 54), the ocellar tubercle of which is often not denuded, and might be supposed wanting.

46. { Crossveins and bifurcation of third vein with distinct brown clouds; lateral whitish spots on abdominal segments distinct . . . . . **47. lasiophthalmus** Macq.
Crossveins and bifurcation of third vein not clouded; lateral whitish or yellowish spots on abdominal segments indistinct . . . . . 47.

47. { 17–20 mm. long. Second joint of palpi narrow . . . . . **48. affinis** Kirby.
15–16 mm. long. Second joint of palpi stout at base. . . . . **49. socius** n. sp.

48. { The lateral whitish spots on abdomen do not[1] touch the hind margins of segments . . . . . 49.
The lateral whitish spots on abdomen rest with their broad base on the hind margins of segments . 50.

49. { Third antennal joint rather narrow, and hardly excised at all; crossveins and bifurcation of third vein without any clouds . . . . . **50. septemtrionalis** Loew.
Third antennal joint moderately broad and distinctly excised; crossveins and bifurcation of third vein with faint brown clouds . . . . . **51. illotus** n. sp.

50. { Second joint of palpi stout at base . . . . . 51.
Second joint of palpi narrow and rather long . . . . . **53. astutus** n. sp.

51. { Bifurcation of third vein without any vestige of a cloud; third antennal joint remarkably narrow, not excised; subcallus not denuded (eastern species) . . . . . **52. microcephalus** n. sp.
Bifurcation of third vein with a faint vestige of a brown cloud; third antennal joint, although narrow, still with a distinctly projecting upper angle; subcallus denuded, black, shining (western species) . **54. rhombicus** n. sp.

DESCRIPTION OF THE SPECIES.

A. Tabani with glabrous eyes, and without ocellar tubercle.

1. Tabanus turbidus.

Tabanus turbidus Wiedemann, Auss. Zw., I, p. 124, 20.

Female. Palpi reddish, with minute black hairs; face yellowish gray, antennæ ferruginous; upper angle of the third joint sharp, projecting, but not drawn out in a point; annulate portion of the third joint rather long, but little shorter than the body of the joint, the single joints composing it very well marked; front yellowish gray, distinctly narrowed anteriorly, darker brown in the middle; frontal callus brownish red, fully twice as long as it is broad; above it a smooth stripe of the same color (sometimes bifurcate at its upper end). Thorax with a grayish pollen, forming more or less distinct longitudinal stripes; the reddish brown or brownish red ground color is distinctly visible between them; scutellum concolorous with the thorax, and also covered with a grayish pollen; pleuræ uniformly dull whitish yellow. Abdomen brownish, with a white spot in the middle of the first segment and with large triangular spots of the same color on segments 2–6; these spots do not differ much in size, that on the sixth segment alone being smaller; the whitish borders on the hind margins of the segments are rather narrow, but expand laterally. Venter brownish red, with whitish incisures. Legs brownish red, hind tibiæ with a but little conspicuous fringe of black hair. All wing veins (longitudinal as well as crossveins) are broadly margined on both sides with brown clouds, the interior of the cells remaining subhyaline; posterior margin of the wings also faintly margined with brown; first posterior cell broadly open. Length, 20–22 mm.

Hab. Georgia (J. Ridings); Kentucky (Wied.). Four females. Will be easily recognized by the peculiar coloring of its wings, the very long and comparatively narrow red-

[1] See the foot-note on page 427; in *T. illotus* the whitish spots on the *second* segment often have the appearance of reaching the hind margin, as the white pubescence, covering them in well preserved specimens, extends to that margin.

dish frontal callus, the long annulate portion of the antennæ, the broadly open first posterior cell, the front coarctate anteriorly, etc. In some specimens the brown clouds along the longitudinal veins are almost evanescent.

The eyes of the female have two purplish green stripes, the lower one bending towards the upper one near the end; their broad interval becomes broader externally.

I have three specimens, one labelled Western States, the second Northern States, the third, Illinois, which, besides almost obsolete clouds on the wings, have the third antennal joint brownish, except at the base. In the plastic characters of the head, and in the broad opening of the first posterior cell, they resemble the typical specimens. I refer them to this species with a doubt.

Wiedemann's description is rather indefinite, but with the aid of some additional information about the typical specimens in Vienna, kindly communicated by Dr. Redtenbacher, I believe I have fully identified this species.

T. fusconervosus Macq. (without locality) may be this species, but the description is too incomplete for identification.

2. Tabanus fronto n. sp.

Female. Palpi reddish, densely clothed with minute black hairs, which give them a brownish appearance; face yellowish gray, cheeks with yellow pile; antennæ ferruginous; basal joints clothed with minute black hair; the upper angle of the third joint sharp, projecting but not drawn out in a point; the annulate apex of the third joint about half the length of the body of the joint, or a little less; front yellowish gray, with a brownish spot in the middle; nearly parallel, and rather broad; callus broad, nearly square, chestnut brown, prolonged in a narrow line above. Thorax with a grayish pollen, forming longitudinal stripes; the reddish brown or brownish red ground color is distinctly visible between them; scutellum of the same color with the thorax, but covered with a grayish pollen. Pleuræ yellowish gray, with blackish hairs in the middle. Abdomen brownish, with a whitish spot in the middle of the first segment, and with whitish triangular spots on segments 2–6; these triangles are smaller than in *T. turbidus*; they are nearly of the same size, except those on the last segments, which are somewhat smaller; incisures whitish, the white border being broader on the sides. Venter brownish, reddish near the basis and with broad whitish incisures. Legs brownish red; the ends of the front tibiæ, the front femora and tarsi brown; the tip of the four posterior tarsi are more or less infuscated; the four posterior femora are beset with black hairs, which give them a darker appearance. The wings have a yellowish brown tinge, more saturate on the basal half; the crossveins at the base of all posterior cells, and the bifurcation of the third vein, are marked with large dark brown clouds; distal end of the first posterior cell distinctly coarctate. Length, 17–18 mm.; some specimens much smaller.

Hab. Georgia (James Ridings). Five female specimens.

This species may perhaps be confounded with *T. trijunctus*; the latter is easily distinguished however, by the ferruginous front tibiæ, not brownish at tip, the dark brown frontal callus; the dark brown scutellum, margined with red behind, etc. The average size of *T. trijunctus* is larger, its general coloring, including the wings, is darker; the white abdominal triangles are larger; the brown spots on the wings are smaller; at the base of the

third posterior cell there is only a vestige of a cloud, while in *T. fronto* the cloud there is nearly equal to that at the base of the second posterior cell.

3. Tabanus trijunctus.

Tabanus trijunctus Walker, List, etc., V, p. 182.

Female. Palpi reddish, dotted with minute black hairs; face grayish yellow, cheeks with yellow pile; antennæ ferruginous; the upper angle of the third joint sharp, projecting, almost rectangular; the annulate portion, in length, about equal to three-quarters of the body of the joint; front yellowish gray, nearly parallel; callus convex, dark brown, rounded above, and with a spindle-shaped prolongation. Thorax reddish brown, with but indistinct stripes of grayish pollen; pleuræ grayish yellow with some blackish hairs in the middle. Scutellum dark brown, its hind border reddish (in well preserved specimens this color is concealed under a covering of golden yellow pile). Abdomen blackish brown; the hind margins of the segments with yellowish white borders, expanding into large triangles in the middle; first and second segments often reddish on each side. Venter brown; hind margins of segments with whitish bands. Legs ferruginous red; front femora, except the tip and front tarsi blackish brown; tips of the other tarsi brownish, hind tibiæ with a distinct fringe of rufous hairs. Wings brownish, tinged with ferruginous on the proximal half and along the costa; brown clouds on the bifurcation of the third vein, and on the transverse vein at the base of the second posterior cell; central crossveins also clouded, posterior cell coarctate. Length, 17–21 mm. I have seen a specimen only 15 mm. long.

Hab. Florida. Seven female specmens, partly from my own collecting, partly from Messrs. Hubbard and Schwarz. (Ft. Capron, Florida, April 21–24.)

The differences between this species and *T. fronto* have been fully explained under the head of the latter.

4. Tabanus fuscopunctatus.

Tabanus fuscopunctatus Macquart, Dipt. Exot., 4e Suppl., p. 34, 108.

Female. Palpi reddish; face grayish yellow in some specimens, with brown hairs on the cheeks, in others these hairs are yellowish; antennæ red; third joint almost crescent-shaped, its upper angle being drawn out in the shape of a curved point, or horn; front grayish yellow; callus chestnut brown, with a linear prolongation above. Thorax of a dark reddish brown, with a slight grayish pollen; a tuft of whitish hairs on each side, between the root of the wings and the scutellum; the latter dark reddish brown; pleuræ clothed with dense yellowish hairs, especially near the humerus, and under the root of the wings; in some specimens there is a tuft of black hairs in the middle. Abdomen reddish brown or blackish brown; a subtriangular small white spot in the middle of the hind margin of segments 1–6; no perceptible white border on the hind margins of the segments, except on the sides, which show the usual triangles of appressed pubescence. Venter brown; incisures yellowish white; in an oblique light the whole venter appears sericeous, from a microscopic whitish pubescence. Legs reddish, sometimes brownish red; hind tibiæ with a distinct fringe of hair. Wings subhyaline on their distal and posterior half; large and well marked blackish brown clouds on the central crossveins, the crossveins at the base

of the second and third posterior cells, and on the bifurcation of the third vein; costal cell, stigma and proximal half of the fifth vein, brownish ferruginous, sometimes brownish; basal cells also somewhat infuscated; extreme tips of the second vein and of the upper branch of the third vein in some specimens slightly clouded with brown. Length, 21–25 mm.

Hab. Florida; South Carolina; Georgia (Macq.); seems to be a common species (Sea Islands, S. C., June 2d, B. P. Mann; Haulover, Fla., March 16, Sand Point, Fla., March 21, E. Schwarz; Indian River, Fla., E. Palmer). I have seven female specimens before me.

This species is easily distinguished from the two preceding by the shape of the third antennal joint, the upper angle of which is drawn out in a long point, the uniformly red or reddish brown coloring of the legs, the more hyaline posterior half of the wings, the much smaller white spots on the abdomen, etc. The shade of the brown on the body is not unlike that of *T. americanus*, which species also resembles *T. fuscopunctatus* in the conspicuous white tufts of hair above the root of the wings, the color and shape of the antennæ, etc. The hairs on the cheeks and pleuræ of this species are very variable in coloring.

T. fuscopunctatus differs in many respects from the group of species (No. 1–11), among which it is here placed, — in coloring and markings, in the shape of the third antennal joint and in the coloring of the eyes. The latter, instead of having the two nearly parallel green stripes, common to all those species, have a single narrow green stripe on purple ground, the lower portion of the eyes being again green.

Macquart describes a damaged specimen, and for this reason does not mention the spots on the abdomen; the description of the antennæ, the comparison to *T. ruficornis* (Syn. *T. americanus* Förster), etc., leaves no doubt about the identification.

5. Tabanus catenatus.

Tabanus catenatus Walker, List, etc., I, p. 148.

Female. Palpi pale reddish; face pale yellowish white; antennæ pale red; annulate portion of the third joint nearly as long as the body of the joint, its upper angle sharp, projecting, but not drawn out; front yellowish gray, callus reddish brown, with a somewhat spindle-shaped prolongation above. Thorax reddish brown, the usual longitudinal lines of yellowish white pollen very distinct; pleuræ yellowish white or whitish yellow, clothed with long hairs of the same color; a short streak of black hair above the root of the wings. Abdomen distinctly attenuated posteriorly, brown above, each segment with a narrow and long white triangle in the middle; sides of the abdomen margined with a yellowish white pubescence; ground color of the venter brown, concealed under a dense microscopic whitish pubescence; incisures whitish. Legs reddish or brownish red, tarsi somewhat darker. Wings slightly tinged with brownish, more distinctly pale reddish brown near the basis and in the costal cell; central crossveins, crossveins at the base of the second and third posterior cells and the bifurcation of the third vein, more or less distinctly, although not very strongly, clouded with brown; the first posterior cell is not perceptibly coarctate. Length, 23–24 mm.

Male. Head but little larger than that of the female, and but a little more convex; large and small facets distinctly separated; the large ones, however, not quite so large as in other species. The abdomen usually a little paler brown than in the female. Length, 20–21 mm.

Hab. New York, Pennsylvania, Maryland, South Carolina (B. P. Mann); Connecticut (Southington, in July; W. H. Patton). I have three males and two females before me.

This species is easily distinguished from its relations by the shape of the white abdominal triangles, which are long and narrow, two or three times longer than broad, and not nearly equilateral, as in the other species. The shape of the abdomen is very peculiar, as it appears laterally compressed towards the tip (I did not take note, however, how the abdomen appears in the living specimens). The brown clouds on the wings are less marked in this species than in the three preceding ones; sometimes they are nearly obsolete.

The eyes of the female have two rather broad green bands on purple ground; the lower band at the end is bent toward the upper one; thus the interval between them, very narrow near the front, becomes broader at the opposite end.

T. catenatus Walker (Massachusetts) seems to agree with this species, although the identification is not certain. The *variety*, described by Walker, Vol. V, p. 172, is a totally different species. *T. recedens* Walker, may also be this species; but the description does not agree so well as that of *T. catenatus*.

6. Tabanus abdominalis.

Tabanus abdominalis Fabricius, Syst. Antl., p. 96, 15. (*Museum Bosc.*)
? Tabanus abdominalis Palisot Beauvois, Ins., p. 101, Tab. II, f. 4. (1809.)
? Tabanus abdominalis Wiedemann, Dipt. exot. I, p. 65, 6; Auss. Zw., I, p. 116, 7.

This species and the next following are either unusually variable, or there are several closely allied species, very difficult to distinguish. With the material which I have before me I am unable to unravel these difficulties, and I believe that they can be solved only by observations made in the localities where these species occur, observations which would define the limits of the variation of each species.

I will first describe here that species, or variety of a species, which I take to be nearest to the original type of Fabricius's description; and having done this, I will proceed to describe the different forms which I have before me, and which may be either mere varieties or distinct species.

An incidental remark of Macquart's, in the introductory paragraph to the genus Tabanus in the first volume of the Diptères Exotiques (p. 116), throws more light on Fabricius's *T. abdominalis* than the author's short descriptions. Macquart names *T. abdominalis* among the species with a closed first posterior cell. Where did he derive the knowledge of the character? *T. abdominalis* does not appear anywhere else in his works, nor is the character mentioned in Fabricius or Wiedemann. The probable and only possible explanation is, that he saw in the Museum of the Jardin des Plantes, the specimen of Bosc's collection originally described by Fabricius, as expressly stated in the Systema Antliatorum (Bosc's collection, as well known, is incorporated in that of the Museum). If the specimens from Fabricius's own collection, which Wiedemann described, or his own specimens, had had a closed first posterior cell, that conscientious and careful author would certainly have mentioned this character, rather unusual among Tabanidæ. Wiedemann's silence proves that the specimens which he saw had the first posterior cell open; in Palisot's figure that cell is also represented as open; and, in fact, the specimens with a closed cell are comparatively rare.

As the original *T. abdominalis* Fab. had the first posterior cell *closed*, we will begin by describing, as typical, the specimens partaking of this character, without inquiring, for the present, whether it is specific or merely adventitious.

Female. Face pale yellowish gray with pale hair on the cheeks; palpi dusky yellowish, with short black hair, which gives them a darker appearance; front rather narrow, brownish, mixed with gray; frontal callus longer than broad, chestnut brown or dark brown, with a somewhat spindle-shaped prolongation above; antennæ red; basal joints clothed with short black hair; third joint rather broad, with a rather rectangularly projecting upper angle; annulate portion black, the region immediately preceding it often more or less brownish. Thorax brownish gray, with alternate gray lines and darker stripes; the former, in well preserved specimens, are clothed with short, golden yellow hairs (visible under the lens only). Pleuræ of a dingy yellowish gray, with hairs of the same color; a fringe of blackish hair above the root of the wings. Scutellum brownish at the base, more reddish posteriorly. Abdomen brownish rufous, with whitish triangles in the middle of the segments, those on segments 2–4 differing but little in size, that on segment five smaller; a distinct black spot clothed with black pile intervenes between the apex of the triangle on the second segment and the hind margin of the first. The hind margins of the segments have borders of fulvous hair on reddish yellow ground, becoming broader laterally; the last segments are darker, the black pile upon them being more dense; the sides of the segments usually have blackish spots, overgrown with black pile, in their anterior corners. Venter yellowish rufous; last segment with some blackish hair. Legs: front coxæ clothed with gray pollen, darker towards the tip; a tuft of whitish hairs near the base, on the outside; front femora, distal half of tibiæ and tarsi, dark brown; proximal half of tibiæ yellowish white; middle legs brown, tibiæ more or less yellowish white on the proximal half; hind femora brown, beset with pale hairs; tibiæ yellowish brown, paler at base, and with a fringe of black hair on the outside; tarsi brown. Wings with a distinct brownish tinge; crossveins at the base of the second, third and fifth posterior cells, as well as the bifurcation of the third vein, with distinct brown clouds; first posterior cell closed, the third and fourth veins uniting a short distance before the margin.

I have three female specimens answering this description; two from the Middle States (probably District of Columbia); one from Illinois; unfortunately, only one of them has the markings on the abdomen well preserved. Length, 18–20 mm.

Having thus described the specimens which come nearest to Fabricius's type, I will proceed to notice the aberrant specimens which I have before me, whether they be varieties or species.

I have fourteen females and three males (principally of my own collecting in the District of Columbia; also from Maryland, Pennsylvania, New Jersey), which resemble the above described *T. abdominalis* very much, but have the first posterior cell open, although strongly coarctate. All the females, at the same time, have a distinctly broader front. In other respects, I do not perceive any prominent distinctive characters. The abdominal triangles in these specimens seem to be narrower and more yellowish, the abdomen appears more uniformly rufous, without distinct black spots on the sides, etc., but as, of the typical form, I have only a single specimen with well preserved abdominal markings, I cannot decide whether the differences just stated are permanent or only accidental. The males have subhemispherical heads, with a well marked dividing line between the large and small

facets of the eye; they are more brownish in color, the abdomen especially; each abdominal triangle has a dark spot at its apex, the lateral margins of the segments, anteriorly, are also marked with black, etc. Length, female, 18–22 mm; the average about 20 mm.; male, 20 mm.

Two well preserved females from Kentucky (F. G. Sanborn) are still darker in coloring; the face and pleuræ, with the hairs upon them, are more yellowish; the abdomen is of a bright reddish fulvous; in the middle of the anterior margin of each segment there is a black spot, small on the second, much larger on the following segments, where it is bilobed; the white triangles are replaced by ill-defined yellowish ones, merging into the yellowish hind margin of segments; the sides of the abdomen are almost uniformly reddish fulvous, with no yellow spots and only vestiges of black ones; wings strongly tinged with brown, darker than in the preceding variety; first posterior cell very much coarctate. Length, 21 mm.

I am inclined to think that *T. abdominalis* is a very variable species, and that all these forms are but varieties of the same species. At the same time I acknowledge that the coincidence of a closed first posterior cell with a narrower front, as I find it in three specimens, cannot be easily explained away, without other facts to invalidate its importance.

7. **Tabanus tectus** n. sp.

Female. Face pale yellowish gray, hairs on the cheeks of the same color; palpi reddish brown, closely beset with short, black hair; front yellowish gray, with a brownish shade in the middle, moderately broad; callosity dark brown, or reddish brown, somewhat convex; the line above it elongate spindle-shaped, sometimes forming a distinctly elevated ridge; two first antennal joints black, or nearly so, the third red, annulate portion black; the narrow portion which precedes it is sometimes more or less brownish; upper angle projecting, nearly rectangular. Thorax brownish, with alternating brownish stripes and narrower whitish lines, and clothed with a yellowish gray pollen; pleuræ yellowish gray, slightly reddish in the middle; this reddish region has some black pile upon it; a fringe of black pile before the root of the wings. Abdomen yellowish brown, with a yellowish spot on the first segment, and yellowish white triangles on segments two to five; those on segments two, three and four, in well preserved specimens, are rather large; that on segment five is small and narrow; no trace of white on the following segments; a more or less distinct blackish spot on the apex of one or two of the anterior triangles; hind margins of the segments whitish yellow, with a golden yellow fringe of hairs, expanding laterally; on each side the anterior corners of the segments are more or less darkened; towards the tip the abdomen is nearly brownish and somewhat compressed laterally, so as to become slightly roof-shaped; venter reddish brown, or brownish red; hind margins of segments yellowish, beset with golden yellow hair. Legs brown; front legs darker; all the tibiæ somewhat yellowish white at the base. Wings with a distinct brownish tinge; crossveins at the end of the discal cell, and bifurcation of third vein, distinctly clouded with brown; crossveins at the base of the two last posterior cells also somewhat clouded; first posterior cell distinctly coarctate.

Male. The upper part of the head is much smaller than in *T. abdominalis* (in the variety, at least, with the open posterior cell); hence, the dividing line between the large and small facets lies much higher here, nearly in the middle of the eye, instead of below the

the middle, and the space occupied by the large facets is much smaller. The whitish yellow pollen on the thorax is more dense, concealing the darker longitudinal stripes; the pleuræ have a tuft of brown hair in the middle; the discs of the discal and the posterior cells are more distinctly grayish, less brown, so that in the discal cell a distinct limit is visible between a brownish shadow at the base and along the fourth vein, and the lighter color of the disc; (the females show the same coloring of the discal cell, but much less distinctly). The abdomen is very distinctly roof-shaped towards the tip. Length, 19–20 mm.

Hab. Six females and two males, caught by myself near Doubling Gap, in the Pennsylvania Mountains.

Three females from Dallas, Texas (Boll), have the abdomen flatter, less roof-shaped; the white abdominal triangles are a little smaller, narrower, but more pointed, and with a more definite outline; there is a distinct white line in the middle of the sixth segment (of which there is not a vestige in the typical specimens); in other respects, the resemblance between these specimens and those from Pennsylvania is very great, and I leave the question of their specific identity in abeyance. I have seen a similar specimen from Tennessee (C. V. Riley), and one from Virginia.

T. tectus resembles *T. abdominalis* in general appearance very much; the male, as noticed above, has a smaller head, the abdomen in both sexes differs in its outline, being more narrowed posteriorly; the coloring of the abdomen is more brownish than reddish, the white triangles broader, less yellowish, the first posterior cell a little less coarctate; the frontal callosity usually darker and a little shorter, etc.

8. Tabanus variegatus.

Tabanus variegatus Fabricius, Syst. Antl., p. 95, 10; Wiedemann, Dipt. Exot., I, p. 67, 11; Auss. Zw., I p. 120, 13.

Tabanus sulcifrons Macquart, Dipt. Exot., 5e Suppl., p. 33, 127 (Macquart has *fulcifrons*, evidently a, misprint).

"Lilacino-rubidus; abdomine badio, albo-maculato; alis fusco-maculatis, margine interno fusco-limbatis."

(*Translation.*) "Antennæ brownish black, root of the third joint reddish yellow; face gray; front cinereous, with a brown, smooth line, and an almost square callosity. Thorax lilac reddish, with five whitish lines, in well preserved specimens with white hairs on the sides, posteriorly. Abdomen chestnut brown, verging into ferruginous brown; the anterior segments on the sides anteriorly with brownish black spots, the fifth and the following almost altogether black; all the incisures, laterally, whitish; the whitish triangular spots in the middle of the segments end anteriorly, on the second and third segments, in a small brown stripe; last segment altogether black. Wings actually of a whitish color (*wirklich von weisslicher Farbe*); costal cell, apex and hind margin pale brownish; crossveins with saturate brown clouds; halteres brown with a whitish knob. Legs brown; base of tibiæ ochre-brown. From Fabricius's collection. Length, 9 lines; (19.5 mm.).

"*Hab.* North America."

I translate Wiedemann's description, because he had Fabricius's specimens before him. I possess three specimens from District of Columbia and Maryland, which agree with this description. The middle portion of their wings is whitish, the hind margin has a distinct

brownish border; the thorax is clothed with a dense whitish pollen, which, with the reddish ground color visible through it, produces the appearance which Wiedemann calls lilac reddish (*lilacino-rubidus*; observe that he calls lilac brownish, the thorax of *T. molestus*). These characters easily distinguish well preserved specimens of this species from *T. tectus*; at the same time they are merely differences in coloring, and not plastic characters, and therefore unsatisfactory. The, as yet, unknown male of this species may afford some characters distinguishing it from the very well-marked male of *T. tectus*.

T. sulcifrons Macq., is this species, as the description of the wings proves. The furrow on the front, mentioned by Macquart, is adventitious, and not a specific character.

At the time when Fabricius described this species (1805), there existed a much older *Tabanus variegatus*, that of DeGeer; as the latter, however, is very probably the same as *Chrysops costatus* Fabricius, I do not see any necessity for proposing a new name for *T. variegatus* Fab.

9. Tabanus molestus.

Tabanus molestus Say, Journ. Ac. Phil., III, p. 31, 1; Wiedemann, Auss. Zw., I, p. 125, 21.

Female. Palpi reddish, clothed with minute black hairs; face white, with white hairs (in older specimens yellowish); front brownish gray, with a brown spot in the middle; frontal callosity chestnut-brown, a little longer than broad, prolonged upwards as a spindle-shaped line. Antennæ black, with some vestiges of reddish on the first and second joints; sometimes the third joint is reddish at the base; its upper angle more or less projecting. Thorax brown, with well marked white longitudinal lines, formed by short white hairs on a whitish ground color; the reddish scutellum in well preserved specimens appears white from a white pollen and white pubescence. Pleuræ white, with white hairs (yellowish in older specimens); a stripe of black hairs between the root of the wings and the humerus. Abdomen dark brown, often nearly black; on the first segment there is a white spot under the scutellum; hind margins of segments with narrow white borders, expanding into white triangles in the middle; the triangle on the second segment is small, hardly reaching the middle of the segment; those on the third and fourth segments are the largest; those on the fifth and sixth segments are again smaller; the white posterior borders of the segments expand on the sides, so as to occupy the whole lateral margin. Venter densely clothed with a whitish microscopic pubescence; incisures whitish; last segments more brownish. Legs black or brown; tibiæ reddish brown, blackish towards the tip; in well preserved specimens the four posterior tibiæ show a dense, white pubescence. Wings subhyaline, slightly tinged with pale brownish; stigma brown; very faint, hardly apparent vestiges of brown clouds on the crossveins and at the bifurcation of the third vein; first posterior cell not coarctate. Length, 18–20 mm.

Hab. District of Columbia, Kentucky (Bee Spring in June, F. G. Sanborn), Georgia, Missouri. Ten females.

The very large size of the white triangles on the third and fourth abdominal segments, in contrast to the small size of the triangle on the second segment and the white scutellum, helps to distinguish this species from those to which it has a superficial resemblance. The stripes on the eyes of the female are very like those of *T. trimaculatus*.

The identification can hardly be called in doubt, although Say does not expressly mention the triangle on the second segment. Wiedemann must have had an older specimen, as he calls the antennæ and the legs brown and not black. The words "Wurzel und Spitze des dritten Gliedes guttgelb," contain some *lapsus*. Dr. Redtenbacher kindly examined Wiedemann's type in Vienna for me, and his answer to my inquiry satisfied me of the correctness of my identification.

10. Tabanus trimaculatus.

Tabanus trimaculatus Pal. Beauvois, Ins. Dipt. Tab. I, f. 5; Wiedemann, Auss. Zw., I, p. 137, 40 (reproduction of Palisot's description); ibid., p. 132, 33 (Wiedemann's own description, doubtfully identified with Palisot's); Macquart, Dipt. Exot. I, 1, p. 142.

Tabanus quinquelineatus Macquart, Hist. Nat. Dipt., I, p. 200, 11.

Female. Palpi whitish yellow, clothed with minute black hairs; face white, with white hairs; front brownish gray, with a brown spot in the middle; frontal callosity reddish brown, seldom dark brown, somewhat longer than broad, with a more or less spindle-shaped prolongation above. Antennæ black, sometimes a little reddish on the first joint; upper angle of the third joint sharp, projecting, but not drawn out in a point. Thorax brown, with well marked white longitudinal lines, formed by short white hairs on a whitish ground color; scutellum clothed with a whitish pollen and pubescence, through which the brownish ground color is visible. Pleuræ white, with white hairs; a stripe of black hairs between the root of the wings and the humerus. Abdomen deep black or brown opaque; on each of the segments three–five a white triangle in the middle; lateral margins of all segments white; (in some specimens the second segment has two very faint whitish dots in the middle, and at a considerable distance from each other). Venter with a broad brown longitudinal stripe in the middle; its sides whitish. Legs: femora black or brown, clothed with a white pubescence; tibiæ yellowish white, black at tip; tarsi black. Wings subhyaline, slightly tinged with pale brownish; stigma brown; faint brownish clouds on the crossveins and on the bifurcation of the third vein; first posterior cell slightly coarctate at the end, in some specimens more than in others. Length, 17–19 mm.

Male. Head subhemispherical, with a distinct demarcation between the large and small facets; in the dry specimen the region occupied by the large facets is whitish, with a broad brown crossband over both eyes; (in this respect very like the male of *T. coffeatus*). Length, 17 mm.

Hab. District of Columbia, Delaware, Pennsylvania, Mississippi, Illinois, Georgia (Ent. Soc. Phil.); Carolina (Macq.). Ten females and one male.

The eyes of the female show two parallel, rather narrow green bands, on purple ground; the interval between them is twice as broad as the bands themselves, and almost equally broad at both ends; (colors revived on moist sand).

Except in the coloring of abdomen and legs, this species has a most striking resemblance to *T. molestus*; (hence Wiedemann, l. c., compares both species). A very characteristic mark of the species (besides the three triangles or segments three–five), and the absence of them on the first and second segments, is the broad brown longitudinal stripe on the venter. The scutellum is less white here than in *T. molestus*, and does not much differ in coloring from the rest of the thorax. The average length of *T. trimaculatus* is smaller than that of *T. molestus*.

The synonymy of Macquart's *T. quinquelineatus* I consider as certain. The description of the venter is especially convincing; ("ventre à large bande noire longitudinale").

11. Tabanus tener n. sp.

Female. Palpi pale reddish, clothed with whitish pollen and white and black hairs; face white, yellowish around the antennæ, with white hairs on the cheeks; front grayish, brown in the middle, yellowish gray above the antennæ; frontal callosity reddish brown, a little longer than broad, with a linear prolongation above; prevailing color of the antennæ black, the vestiges of reddish on the first two joints are almost concealed under black hairs; base of the third joint more or less, sometimes hardly perceptibly, reddish; upper angle of this joint well-marked, but not very sharp. Thorax lilac-reddish, with the usual white lines formed by a grayish pollen; the pale reddish ground color of the pleuræ is almost concealed under a whitish pollen and white hairs; a fringe of brown hairs from the humerus backwards; a small tuft of blackish hairs in front of the scutellum. Abdomen of the same color as the thorax, which color is softened by a thin layer of whitish pollen; the segments have large but faint and easily rubbed off triangles in the middle, formed by a short white pubescence on whitish ground; lateral margins also whitish. Venter of the same color as the abdomen, with the same thin covering of whitish pollen and whitish incisures. Front legs dark brown, proximal half of the tibiæ lighter brown; four posterior legs reddish brown, with whitish hairs. Wings subhyaline; very faint, almost obsolete, brownish clouds on the bifurcation of the third vein and at the base of the second posterior cell; stigma brown; first posterior cell not coarctate. Length, 17–18 mm.

Hab. Georgia (J. Ridings); Indian River, Florida (E. Palmer). Four females.

This species is difficult to describe from the want of any well-marked characters. It is distinguished by a peculiar soft reddish brown coloring, and the faintness of the white abdominal triangles, which are very easily rubbed off. The comparatively small thorax and somewhat narrow abdomen make its shape appear more elongated than that of the other species of the same group. The evanescent spots at the base of the bifurcation of the third vein and of the second posterior cell will also facilitate its recognition.

The eyes (softened on moist sand) showed two faint greenish crossbands, converging at the outer end. For some time I thought that this might be *T. gracilis* Wied.; but Wiedemann gives the size as five and two-thirds Rhenish lines, while it should be eight and one-half in order to render the identification possible.

12. Tabanus melanocerus.

Tabanus melanocerus Wiedemann, Auss. Zw. I, p. 122, 16.

? Tabanus exæstuans Linné, Syst. Nat., II, p. 1000, 8; DeGeer, VI, p. 229, 8; Tab., XXX, f. 5; Fabricius, Ent. Syst., IV, p. 365, 13; Syst. Antl., p. 96, 12.

Female. Palpi whitish, clothed with minute black hairs; face white, with white hairs; front brownish, mixed with gray; frontal callosity reddish brown, sometimes dark brown, longer than broad, with a linear prolongation above; antennæ black, more or less reddish at the basis of the third joint; this joint is broad, its upper angle projecting. Thorax gray, with whitish longitudinal lines; (the color of the thoracic dorsum and scutellum in somewhat worn specimens shows traces of reddish; but in a very fresh and well-preserved spec-

men from Florida, it is of a dull cinereous, with whitish lines; its surface is clothed with short black hairs, especially apparent at the base of the scutellum). Pleuræ grayish white, with white hairs; a fringe of black hair between the humerus and the root of the wings. Abdomen black or dark brown; the hind margins of the segments have white borders, expanding into large white triangles in the middle, and becoming broader towards the lateral margins; segments six and seven show but vestiges of white. Venter brown, or reddish brown, more whitish on the sides; hind margins of segments white. Legs: femora black or brown, the four posterior ones with whitish hairs; tibiæ yellowish white, blackish at tip; distal half of front tibiæ black. Wings grayish subhyaline; stigma brown, its environs sometimes faintly tinged with brownish; first posterior cell considerably coarctate at the tip, sometimes nearly closed. Length, 17–19 mm.

Hab. Mississippi, Alabama, Georgia (J. Ridings); Cedar Keys, Florida (June 4, E. Schwarz); Kentucky (Wied.). Five females.

The identification of Wiedemann's description cannot be doubtful, as the coarctate posterior cell easily helps to recognize this species. There is a superficial resemblance between *T. melanocerus* and *T. molestus*, but they are easily distinguished by the size of the triangle on the second abdominal segment, which is nearly of the same size as on the third segment in *melanocerus*, but two or three times smaller in *molestus*. *T. melanocerus*, like *T. coffeatus*, has no crossbands on the eyes.

I have seen this species in some European collections under the name of *T. exæstuans* Linn., the original type of which, figured in DeGeer, was from Surinam. There is nothing in the descriptions of Linné, DeGeer[1] and Fabricius, to prevent this identification. At the same time, in view of the shortness of these descriptions and of the difference in the locality, it will be safer to retain Wiedemann's name, the identification of which cannot in the least be doubtful. Wiedemann quotes *T. exæstuans* among the species he had not seen.

13. Tabanus coffeatus.

Tabanus coffeatus Macquart, 2e Suppl., p. 23, 109; *male.*
? Tabanus nigripes Wiedemann, Auss. Zw., I, p. 142, 50; *male.*

Female. Palpi yellowish white, clothed on their distal half with minute black hairs; face white, with white hairs; front dark grayish, mixed with blackish brown; frontal callosity reddish brown or dark brown, but little longer than broad, with a linear prolongation above; subcallus often denuded; antennæ black, a vestige of reddish at the base of the third joint; this joint rather broad, its upper angle obtuse. Thorax gray, with whitish longitudinal lines; (well preserved specimens show a broad stripe of gray pollen, more dense on each side, and with a fine longitudinal line in the middle). Pleuræ grayish white, with white hairs mixed with a few black ones; a fringe of black laid between the humerus and the root of the wings. Abdomen brownish black; the hind margins of the segments have white borders expanding into large white triangles in the middle, and becoming broader towards the lateral margins; segments six and seven show but vestiges of white. Venter brownish black, hind margins of the segments white. Legs black; tibiæ more or

[1] DeGeer's figure shows broad abdominal crossbands and no triangles, which, if correct, would be against the identification with *T. melanocerus*.

less brownish at base; the legs are clothed with whitish hairs, especially on the tibiæ; but they appear to have that color in a certain light only. Wings grayish subhyaline; stigma brown; first posterior cell not coarctate. Length, 13–14 mm.

As the description shows, this species very much resembles *T. melanocerus*; it differs principally in its smaller size, the much darker coloring of the tibiæ, and especially in the first posterior cell not being coarctate at all. The eyes in this species, as in the preceding, are uniformly colored in life, and not banded.

Male. Altogether brownish; thorax with a broad stripe of grayish pollen anteriorly, which is darker in the middle (thus producing the appearance of two stripes, separated by a dark interval); abdomen with rather narrow whitish gray posterior borders on the segments, expanded into small triangles in the middle; on the venter the same whitish hind borders of the segments; pleuræ clothed with blackish hair; legs dark brown, tibiæ faintly reddish. Wings nearly hyaline, stigma brownish; sometimes a faint brownish cloud behind it. Head large; subhemispherical; in dry specimens the lower, small facets are black, the upper ones have a broad brown crossband on whitish ground. Antennæ brown, third joint reddish at the base; face brownish gray, beset with black hairs; palpi black; subcallus brown (denuded in both of my specimens). Length, 13–14 mm.

Hab. District of Columbia; Delaware; New York; Florida (Waldo, Fla., 2d June, 1875, Messrs. Hubbard and Schwarz); one of the males is from Massachusetts. Ten females; two males.

I little doubt that the above described male and female belong to the same species, and on this assumption I adopt the name *coffeatus*, as Macquart describes the male only. The identification of his description seems certain to me. The words "partie antérieure du front à callosité brune," are particularly convincing. It is not usual to speak of the callosity in describing a male specimen; but in the present species the *subcallus* in both sexes is often denuded, and for this reason attracted Macquart's attention. This circumstance would also serve to confirm, if any confirmation were needed, the specific identity of the two sexes.

Wiedemann's description of *T. nigripes* (he also had a male specimen) agrees very well with the male of *T. coffeatus*, only the size (7 German lines = about 15.3 mm.) is a little too large. Between the two descriptions I preferred the one which I considered the more certain.

14. Tabanus Orion n. sp.

Female. Palpi dark brownish red, clothed with short black hairs; face yellowish white, with yellowish white hairs; front whitish yellow above the antennæ; brownish, mixed with yellowish and grayish above the frontal callosity; the latter longer than broad, attenuated above and gradually merging in the linear prolongation; its color, in all my specimens, is brownish red. Antennæ reddish; first joint with some black hairs above; third joint, red at the base only, otherwise black; upper corner well marked. Thorax reddish brown, clothed with a whitish pollen, forming more or less distinct whitish lines (the appearance of the thoracic dorsum is very variable in this species, according to the degree of preservation, or perhaps also to the age of the specimen at the time of its death; in well preserved spec-

imens I perceive a short, black pubescence, covering the whole dorsum). Pleuræ brown, clothed with dense whitish pollen and white hairs; a fringe of black hairs back of the humerus. Abdomen brown, with a comparatively small triangular or subtriangular white spot in the middle of the hind margins of each segment; lateral margins of the segments whitish. Venter brown, with a whitish pollen on the sides, leaving a more or less distinct broad, brown longitudinal stripe in the middle. Legs almost uniformly reddish brown, tips of front tibiæ and the tarsi but little darker. Wings unicolorous, very distinctly tinged with pale brownish; first posterior cell broadly open. Length, 23–25 mm.

Male. I have a single specimen, which, I have no doubt, belongs to this species. The face is brownish gray; the body more uniformly brown. The head is large, but less subhemispherical than in *T. abdominalis*, *coffeatus* and *trimaculatus*; the division of the large and small facets is well marked; the eyes, in the dry specimen, are altogether unicolorous. Length, 20–21 mm.

Hab. Canada (Bélanger, Couper, Provancher); Nahant, Mass. (Prof. L. Agassiz); Suffield, Conn. (G. Dimmock); Beverly, Mass. (E. Burgess). The male specimen is from the State of New York. I have eight females and one male.

This species will be easily distinguished from *T. Actæon* by its large size, the coloring of the abdomen, the non-coarctate first posterior cell, etc.; but most easily by the coloring of the front tibiæ, which in *T. Actæon* are almost whitish yellow at the base, and much darker towards the tip. The eyes of *T. Orion* ♀, seem to be unicolorous; at least softening on wet sand did not bring out any stripes on them.

15. Tabanus Actæon n. sp.

Female. Palpi brownish red, densely clothed with short black hairs; face whitish, with white hairs; front grayish, mixed with brownish in the middle; in well preserved specimens with some short blackish hairs on the vertex; frontal callosity dark brown (in one of the specimens brownish red), tapering off into a linear prolongation. Antennæ reddish, with black hairs on the basal joints; third joint reddish at base, the remainder dark brown and black; its upper angle sharp, projecting; the narrow portion of the third joint is rather elongate. Ground color of thorax reddish brown; nevertheless the prevailing color of the dorsum is black, in consequence of four black, nearly coalescent stripes, the two middle ones not reaching the scutellum; these black stripes, in well preserved specimens, are separated by lines of gray pollen. Pleuræ grayish white. Abdomen brownish red or reddish brown; a comparatively small white triangle in the middle of the hind border of each segment, surmounted by a dark spot, which connects it with the edge of the preceding segment; incisures and lateral margins of segments whitish. Venter clothed with a dense whitish pollen, and with a broad brown longitudinal stripe in the middle. Femora brownish, with whitish pollen and whitish hairs; front and middle tibiæ whitish yellow, brown towards the tip; the hind tibiæ brownish yellow or yellowish brown. Wings unicolorous, with a uniform, pale brownish tinge; first posterior cell very slightly attenuated. Length, 19–21 mm.

Hab. Massachusetts; Connecticut; Minnesota; Wisconsin; Canada. Seven female specimens. The eyes of this species seem to be unicolorous.

16. Tabanus cymatophorus n. sp.

Female. Face whitish, with white hairs on the cheeks; palpi brown, densely clothed with black hairs; front grayish, with a yellowish tinge immediately above the antennæ, and a brownish one above the callosity; the latter suboval, dark brown, prolonged in a line above; vertex gray; antennæ reddish brown, third joint dark brown towards the end. Thoracic dorsum grayish, with four broad blackish stripes separated by grayish lines; sides of the dorsum gray, separated from the pleuræ by a fringe of blackish hairs; tufts of longer white hairs between the root of the wings and the scutellum; a small brown triangle above the scutellum, which is yellowish gray, with minute white hairs; pleuræ and pectus white, with white hairs. Knob of halteres brown, whitish at tip. First abdominal segment white, with brownish indistinct spots at the base; segments two–four brown at base, which color expands into triangles on each side and into two diverging lobes in the middle; the posterior half of these segments is white, expanding into triangles, which fill out the intervals between the brown color; segments five and six show the same markings, only less distinctly. Venter brownish, on each side thinly clothed with whitish pollen, which thus leaves a broad brownish longitudinal stripe in the middle; hind margins of segments whitish. Legs black, base of tibiæ white, which color occupies more than half of the tibia on the intermediate pair, and less than half on the two other pairs. Wings subhyaline; dark brown clouds on crossveins, at the base of all posterior cells, and on the bifurcation of third vein; stigma yellowish brown, rather pale; first posterior cell coarctate at its distal end. Length, 20 mm.

Hab. Kentucky, near Mammoth Cave (F. G. Sanborn). A single, but very well preserved specimen.

This species is not unlike *T. Reinwardtii* Wied. in its general appearance and coloring, but is much larger, the palpi are darker, the frontal callosity more elongated, the coloring of the legs altogether different, the white design on the abdomen much better defined, especially the middle triangles, which are larger, and connected posteriorly with the lateral ones by a broad white border, etc.

17. Tabanus venustus n. sp.

Female. Face yellowish white; palpi brownish, clothed with minute black hairs; front grayish yellow above the antennæ, grayish brown above the callosity, and with a pair of dark brown spots in the middle; callosity brown, not occupying the whole breadth of the front, its linear prolongation not distinctly connected with it. Thorax brown, with longitudinal white lines; scutellum clothed with whitish pollen. Abdomen brown, with white triangles in the middle of the segments; they are especially large on the second, third and fourth segments; segments three–six, on each side of the triangle, show a white spot. Venter brownish, with whitish pollen, which leaves a broad brown longitudinal stripe in the middle. Feet brown. Wings variegated with brown, as follows: the root hyaline; immediately beyond the humeral crossvein a broad brown crossband, reaching the posterior margin; another narrower and shorter crossband covering the crossveins at the base of the marginal, first posterior and discal cells, is almost confluent with the first; the whole posterior margin is bordered with pale brown, which border, being continued around the apex to the anterior

margin, expands into a large spot, coalescing with brown clouds at the origin of the fork of the third vein and at the end of the discal cell; first posterior cell distinctly attenuated.

Male. Surroundings of the mouth and palpi clothed with blackish hair; spots on the abdomen replaced by broad whitish crossbands, especially on segments two to four; in other respects like the female. Length, 14–15 mm.

Hab. Dallas, Texas (Mr. Boll). A male and a female. Missouri, in July (C. V. Riley).

The variegated wings of *T. venustus* being unique among the North American species, will render it easily recognizable. The head of the male is comparatively small, not larger than that of the female; the large facets occupy their usual place, but the difference in size between them and the small ones is so small that it requires a close attention to discover it.

18. Tabanus psammophilus n. sp.

Female. Palpi short and stout, pale yellowish white; face white, with white hairs; front gray, remarkably broad, somewhat convergent anteriorly; callosity black, broader than long, without any linear prolongation above; antennæ pale reddish yellow; third joint tinged with brownish; its annulate portion black; in shape the third joint is comparatively narrow, and not excised at all above, so that its upper angle is very little marked. Ground color of the body dark, but almost entirely concealed under a white pubescence. Legs yellowish, tips of tibiæ and tarsi brownish. Wings whitish, with brown veins; a long stump of a vein near the origin of the upper branch of the third vein; first posterior cell not coarctate.

Male. Similar to the female, except in the sexual characters. Length rather variable, from 11 to 15 mm.

Hab. Ft. Capron, Florida, April 10, 1875 (Messrs. Hubbard and Schwarz), on the sea beach; four males and three females.

The uniformly whitish coloring of this species, the broad front, the transverse frontal callosity, the long stump of a vein on the fork, etc., render the species very easily recognizable. I suppose that it is uniformly white in life; most of the specimens before me seem to have somewhat suffered from moisture, and have for this reason a darker coloring.

In the male the difference between the large and small facets on the eyes is very marked, the latter occupy a comparatively small space on the underside, and are but little prolonged along the posterior orbit. On the eyes of the female I perceive two approximate, bluish stripes on green ground, the upper and lower portion of the eye being again dark blue (or, in other words, the ground color is blue, with two broad green stripes, the broad interval between which contains a third, much narrower green stripe).

Tabanus nanus Macquart. Dipt. Exot. Suppl., 1, p. 42, from Texas, reminds one of the present species; but the size given (four lines) is by far too small for identification. At any rate the name *nanus* cannot be used, being preoccupied by Wiedemann for a species from the Cape.

19. Tabanus nivosus n. sp.

Female. Front of moderate breadth, parallel, brownish gray, with brown shadows; frontal callus pale brown, with a stout linear prolongation above; face white, beset with white

down; palpi rather stout at the base of the second joint, yellowish white, beset with blackish hairs at the tip. Antennæ: first joint reddish yellow, with a tuft of black hair on the upper end; third joint black, yellowish at the extreme base only; excision shallow, and hence, upper angle but little projecting; basal portion rather broad; annulate portion short, stout. Thoracic dorsum dark brown, with faint whitish longitudinal lines; the sides, including the humeri, reddish; beset with sparse golden yellow and whitish hairs; scutellum dark brown, beset with the same hairs. Pleuræ yellowish, with long, soft, white hairs. Abdomen whitish pollinose, beset with a short, white pubescence; in the middle of each segment a bilobed (or truncate obcordate) brownish black spot, the largest on the second segment, and diminishing in size on each successive segment; the sides of the segments (except the first) are brownish, this brown border gaining in breadth towards the end of the abdomen. In badly preserved specimens the reddish ground color of the white portions of the abdomen appears. Venter grayish. Front legs brown, except the proximal two thirds of the tibiæ, which are whitish yellow; four posterior legs reddish yellow; femora and tips of tarsal joints brownish; tips of tibiæ very slightly infuscated; all the coxæ and femora clothed with soft hairs; tibiæ with short, whitish pile; the hind tibiæ have a fringe of hair, which, in a certain light, appears whitish. Wings almost hyaline; stigma pale brown; the bifurcation and some of the crossveins have brown shadows, visible under the magnifying glass only; first posterior cell not attenuated.

Male. The white coloring of the abdomen, interrupted only by the middle row of bilobed blackish spots, is very striking in my only specimen; the face, and the hairs upon it, are brownish gray (not white, as in the female); the legs are somewhat darker; the white lines on the thorax are not visible. Head larger than that of the female, although not subhemispherical; on the eyes there is a yellowish border above the line of separation, between the larger and the smaller facets. Length about 13 mm.

Hab. New Jersey; one male and two females (communicated by the American Entomological Society).

The coloring of the eyes (revived by moisture) in the female proved to be green, with a faint vestige of a single purple crossband.

20. Tabanus vivax n. sp.

Tabanus marginalis Wiedemann, Auss. Zw., I, p. 166, 84.

Male. Face gray, with whitish hairs below, and blackish ones on the sides; second joint of palpi reddish, with a gray pollen and with whitish and blackish hairs; frontal triangle (above the antennæ) gray, black or brown at the tip; antennæ: basal joints reddish yellow, with black hairs, third joint black, reddish yellow at the extreme base only, elongate, of moderate breadth, but little excised above, the upper angle moderately projecting. Thorax grayish black, with white longitudinal lines, abbreviated posteriorly; pleuræ and pectus grayish, clothed with long whitish hairs. Abdomen black; on the first segment a small white spot under the scutellum; on each of the following segments a triangular white spot on the hind margin, and an oblique lateral white spot on each side, angular in shape (owing to its being prolonged along the hind margin); on the second segment these lateral spots are distinctly larger than the triangle in the middle; they become smaller on the

third and fourth segments. Venter blackish, clothed with a white pollen, and with whitish incisures. Legs black, beset with whitish hairs; tibiæ more or less reddish at base. Wings hyaline, stigma brown; first posterior cell open. Length, 14 mm.

The description was drawn from a very well preserved specimen which I took at Trenton Falls, in July, 1874. I have another, less well preserved specimen, from Maine. I also refer to this species a female, from a doubtful locality (Massachusetts?) too much faded, however, to make it worth while to describe it.

The shape of the head of the described male specimens is very like that of *T. nivosus*. it is rather large, but not subhemispherical; there is a very well marked division between the large and the small facets. In size and shape the males of these two species are very much alike, but are easily distinguished by the prevalence of the whitish color on the abdomen of the one, and of the black on the abdomen of the other.

I introduce this imperfectly described species only to draw the attention of collectors to these closely related species, which, in outward appearance, bear also much resemblance to *T. astutus* and *T. microcephalus* of the group with pubescent eyes and small-headed males. (Compare the observation at the end of the description of *T. astutus*.)

Wiedemann's description of *T. marginalis* (female) applies better to the present species than to any other, proper allowance being made for the difference of sex. Nevertheless, the identification is very doubtful; nor is it certain whether Wiedemann and Fabricius, whom he quotes, described the same species.

21. Tabanus longus n. sp.

Female. Front moderately broad, brownish cinereous, with blackish hair; callosity square, black, rather convex; above it, and connected with it, an indefinite, elongate, blackish and somewhat shining spot; antennæ: two basal joints reddish, clothed with blackish hair; third joint variable in coloring, either blackish, with the base alone reddish, or reddish, with the annulate portion black; the body of the joint is of moderate breadth, with a well marked, although obtuse, upper angle; face white, with white down; palpi rather stout, yellowish white, with small black hairs. Thorax grayish black, with very faintly marked gray lines; sides of the dorsum often reddish; pleuræ and pectus grayish white. Abdomen rather long and comparatively narrow (the sixth segment longer than in the allied species, but little shorter than the preceding one), grayish black, sometimes reddish on the sides, near the base; on segments one to six on each side a row of well marked, oval, oblique, whitish spots, usually (but not always) not coalescent with the whitish hind margins of the segments; in the middle of the abdomen a faint, whitish, longitudinal line, expanded at the incisures, thus forming a series of faint triangles, with a rather broad basis, but a very narrow, linear apex. Venter light gray, clothed with minute white hairs; the sides are sometimes reddish. Legs reddish brown, clothed with a grayish pollen; tarsi brown, the basis of the four posterior tarsi paler. Wings grayish hyaline; costal cell pale yellowish brown; stigma pale brown; first posterior cell broadly open. Length, 12–14 mm.

Hab. Middle States (Mus. Comp. Zool. and Am. Ent. Soc.). Four female specimens. A fifth specimen is larger, and has the front distinctly coarctate anteriorly.

This species is distinguished by its slender form and elongated abdomen. Species closely competing in length seem, however, to exist in the South, which, in some cases, may render its recognition doubtful.

I have seen a specimen from Florida (Ft. Capron, March 26; Messrs. Hubbard and Schwarz) only 11 millim. long, of a purer, almost whitish gray; markings of the abdomen very distinct; oblique spots on second segments in contact with the hind margin, those of the third nearly so; costal cell subhyaline; front rather broad, etc. It seems to be a different species.

Two specimens from Texas (Waco, Belfrage, in Mr. Burgess's collection) are more reddish in color; there is a faint brownish cloud on the bifurcation of the third vein, etc. They also seem to belong to a different species.

22. Tabanus pumilus.

Tabanus pumilus Macquart, Dipt. Exot., I, 1, p. 146, 51.

Female. Palpi stout, whitish, with some black hairs; face grayish white; front brownish gray, convergent anteriorly; callosity brownish or black. Antennæ reddish; third joint remarkably broad and comparatively short; its annulate portion short and stout, sometimes infuscated. Thorax blackish gray, with white lines, sometimes reddish on the sides. Abdomen blackish, segments with white hind margins, expanding into small triangles in the middle (often obsolete); on each side of these triangles oblique oval white spots, not coalescent with the hind margins; the sides of the abdomen often appear reddish (especially when denuded). Legs pale reddish yellow, clothed with whitish pollen and white hairs; tips of tibiæ brown; tarsi brown, base of the four posterior ones paler. Wings hyaline; stigma pale brown; first posterior cell broadly open. Length, 8½–10 mm.

Male. Head very large and broad; division between the large and small facets very marked. Third antennal joint less broad; its annulate portion more drawn out in a point. Abdomen reddish brown, the intermediate, triangular white spots almost obsolete, etc. (As I have only a single, somewhat damaged specimen, I refrain from a more detailed description.) Length, 10 mm.

Hab. Middle and Southern States (Maryland; West Point, N. Y.; Enterprise, Fla., May 11–13, by Messrs. Hubbard and Schwarz). Seven females and one male.

T. pumilus will be very easily distinguished by its small size, the peculiar broad shape of the third antennal joint, the convergent front of the male, etc.

Macquart says: "deuxième cellule sous-marginale ordinairement appendiculée." Two of my specimens indeed show a vestige of a stump; but this seems to be an exceptional case.

23. Tabanus lineola.

Tabanus lineola Fabricius, Entom. Syst., IV, p. 369, 33; Syst. Antl., p. 102, 41.—Coquebert, Illustr. Icon., p. 112, Tab., XXV, f. 6.— Wiedemann, Dipt. Exot., I, p. 81, 36; Auss. Zw., I, p. 170, 89.— Harris, Ins. N. Engl., 3d edit., p. 602, fig. 262.—Palisot-Beauvois, Dipt., Tab. II (somewhat doubtful).

Tabanus simulans Walker, List., etc., I, p. 182. Nova Scotia.

? Tabanus scutellaris Walker, Dipt. Saundersiana, p. 27.

Female. Palpi rather stout at the base, yellowish white, beset with short black hairs; face white, with white hairs; subcallus grayish yellow; front dark yellowish gray, distinctly

narrowed anteriorly; callosity black, nearly square, with a short linear, sometimes spindle-shaped prolongation above. Antennæ brownish red, annulate portion black; upper angle of third joint well marked. Thorax grayish black, with white lines; in well preserved specimens these lines, as well as the sides of the scutellum, are beset with a short, yellowish pubescence; the scutellum is often, but not always, reddish at the tip, which appears only in denuded specimens; humeral callosity reddish; pleuræ whitish gray. Abdomen brownish black, with a longitudinal, very well marked, whitish or yellowish stripe along the middle, ending at the hind margin of the sixth segment; this stripe is formed by a grayish pollen as ground color, which is beset with a yellowish pubescence; two lateral stripes of the same color, subconvergent at both ends, are formed by a series of oblique spots on the segments. Venter whitish, being clothed with a dense whitish pollen and a whitish pubescence (in some well-preserved specimens the venter is reddish yellow, beset with yellowish hairs; last segment black, beset with black hair); a dark, ill-defined, longitudinal stripe is sometimes visible. Legs: femora dark, paler towards the tip (in some cases pale yellow, except at base), beset with gray pollen and white hairs; tibiæ pale yellow, the front pair black on its latter half; front tarsi black, the four posterior ones brown, yellowish at base. Wings hyaline, stigma pale brownish; costal cell nearly hyaline; first posterior cell sometimes broadly open, in other cases gently attenuated.

Male. Head not very different in size and outlines from that of the female; line of division between the large and small facets distinct; thoracic and abdominal stripes less well marked. Length, 12–14 mm.

Hab. North America, including Mexico; this is one of the most common species in the United States; occurs abundantly in the States along the Atlantic Coast, also in Florida, Texas, Iowa, etc.

The shape of the front, attenuated anteriorly, the hyaline costal cell and the sometimes reddish scutellum, will help to recognize this species in all its varieties. It varies both in size and coloring; the dorsal stripe has sometimes perfectly even edges, sometimes it is jagged, being expanded at every incisure; the same is the case with the lateral stripes. I have already alluded to the striking differences in the coloring of the venter. The eyes of the female are banded, the upper band being interrupted before reaching the outer margin of the eye.

The identification of Fabricius's short description is rendered certain by Coquebert's figures, which he quotes in the Systema Antliatorum.

The mention of the end of the scutellum being reddish in Walker's description of *T. scutellaris*, renders its synonymy with *lineola* very probable; I do not understand, however, the description of the gray abdominal middle stripe, "which ceases on the tawny hind borders of each segment."

The synonomy of *T. simulans* I look upon as certain.

24. Tabanus nigrovittatus.

Tabanus nigrovittatus Macquart, Dipt. Exot., 2e Suppl., p. 24, 111.

Female. Face whitish, palpi pale yellowish white, with some minute, scattered, black hairs; front parallel, yellowish-gray; frontal callosity dark brown or black, a short, spindle-shaped blackish line above it, and usually disconnected from it; antennæ reddish, annulate

portion rather long, black (in some specimens the third joint is brownish). Thorax blackish-gray, with a pale yellowish pubescence and scattered black, erect pile; no whitish lines, but a hardly perceptible vestige of a broad, longitudinal stripe of purer gray in the middle. Pleuræ dull yellowish gray. Abdomen with a whitish longitudinal stripe, running from the scutellum to the end of the sixth segment; it is enclosed between two blackish stripes running beside it; on each side of the blackish stripe there is again a very faint whitish one, usually visible on segments four to six only; base of the first segment blackish, but sides of segments one to three reddish. Venter reddish at base, with more or less black in the middle in the shape of a stripe, blackish towards the tip. Femora black, clothed with grayish pollen, the tips pale reddish; front tibiæ black, reddish brown on their proximal half; front tarsi black; four posterior tibiæ reddish, except the tip, which is infuscated (more so on the hind than on the middle pair); tarsi brown. Wings hyaline, costal cell yellowish, stigma yellowish. Length, 9–11 mm.

Male. Like the female, but the thorax somewhat darker, the yellowish pubescence being less apparent, and the black erect pile more so and longer; face more grayish; the head, in size and outline, not very different from that of the female. Length, 10 mm.

Hab. Massachusetts, Rhode Island, New York, New Jersey, especially near the sea-coast; (Cambridge, Mass., June 28–July 15, P. R. Uhler and O. Sacken; Salisbury Beach, Aug. 25, in numbers, B. P. Mann). I have sixteen females and ten males. The eyes are like those of *T. costalis*, light green, with a single purple crossband in the middle; it seems to me that this band is somewhat narrower here.

This species has some resemblance to *T. costalis* Wied., but is much smaller, and less yellow on the thorax; face and palpi also less yellowish; the black abdominal stripes enclosing the whitish ones are less dark; the white stripe between them is much less distinctly marked than in *T. costalis*; the hind tibiæ are only slightly brownish here at the tip, while in *T. costalis* the tip is very distinctly and rather abruptly black.

The males, especially, are easily told apart, the thorax of *T. nigrovittatus* ♂, being blackish, that of *T. costalis* very distinctly yellow; in *T. nigrovittatus* ♂, there is, on each side of segments one to three of the abdomen, an oval rufous spot, leaving a well defined, broad, blackish stripe in the middle, in the middle of which the white stripe is running; in *T. costalis* ♂, the extent of the rufous on the abdomen is much more variable, and hence the black stripe in the middle less constant and well defined. From *T. lineola* the present species differs in the smaller size, parallel front, less pure whitish, more yellowish white face, the yellowish tinge of the costal cell, etc.

I see no objection against identifying this species with Macquart's description, except the "une tâche testacée en avant des ailes et sur les côtés du bord postérieur," which I perceive only in the male, while Macquart describes the female. Before identifying this species with Macquart's I distributed specimens to several correspondents under the name of *T. pauper*.

25. Tabanus costalis.

Tabanus costalis Wiedemann, Auss. Zw., I, p. 173, 94; (?) Bellardi, Saggio, etc., I, p. 63.
Tabanus vicarius Walker, List, etc., I, p. 137; *female*.
(?) *Tabanus baltimorensis* Macquart, Dipt. Exot., 5e Suppl., p. 34, 129.

Female. Face yellowish white, palpi yellow, with short and rather dense black hairs; second joint rather stout at base; front grayish yellow, very slightly narrower anteriorly,

nearly parallel; callosity black, with an indistinct prolongation above; antennæ reddish, annulate portion of the third joint black, nearly as long as the body of the joint; the latter somewhat broad, with a distinctly projecting upper angle. Thorax grayish yellow (a gray ground color being clothed with golden yellow hairs). Abdomen with a conspicuous longitudinal yellowish white stripe in the middle, somewhat expanded at each incisure, and two lateral stripes, very much attenuated posteriorly, and formed of a series of oblique, almost coalescent spots, one on each segment; the intervals between the central and the lateral stripes are black (which color thus forms two distinct, well marked, nearly parallel stripes, enclosing on both sides the central pale stripe); the two lateral stripes are bordered on the outside by a second pair of more or less distinct black stripes, formed by a series of black oblique spots, one on each segment; when these spots are less distinct, the lateral pale stripes almost coalesce with the reddish yellow lateral margins of the abdomen; on segments five and six the black prevails, but in well preserved specimens both central and lateral stripes are still visible. All the pale colored portions of the abdomen show, under the magnifying glass, a dense covering of golden hairs. Venter reddish yellow, mixed with blackish, especially towards the tip, both colors being softened by a dense covering of yellowish hairs. Legs black; front tibiæ yellowish at base, four posterior tibiæ yellow, except the tip, which is black; femora clothed with a dense yellowish gray pollen. Wings grayish hyaline; costal cell with a distinct brownish yellow tinge; first posterior cell broadly open.

Male. The black abdominal stripes are usually less dark, and hence, less well defined; especially the base and sides of the abdomen are usually more reddish. Length, 10–13 mm.

Hab. A common species in the Middle and Western States; according to Bellardi, also in Mexico.

I have seen specimens from Florida (Lake Harney, May 5; Messrs. Hubbard and Schwarz), very small (9–10 mm.), and very like *T. nigrovittatus* in appearance; nevertheless I would rather refer them to *T. costalis*. One of them had the third antennal joint entirely black.

The eyes of the female are light green, with a single purple crossband in the middle.

I accept the traditional and very probable interpretation of Wiedemann's description of the male, although, taken literally, it would render the identification doubtful. I am not sure about the interpretation of Mr. Bellardi's description.

T. vicarius Walker is most probably this species; perhaps also *T. baltimorensis* Macq.

26. Tabanus fulvulus.

Tabanus fulvulus Wiedemann, Auss. Zw., I, p. 153, 66.

Male and female. Front and vertex clothed with grayish fulvous pollen; callosity (♀) nearly square, brownish or blackish; above it, but not connected with it, is a short, stout, smooth line of the same color; face and cheeks whitish (see the observation at the end); palpi (♀) rather stout, pale yellowish white, with blackish hairs; in the male they are whitish; antennæ: first joint reddish yellow, with black hair; third joint red; its upper angle well marked and projecting, its annulate portion black or brown, much shorter than the remaining portion of the joint; (in my only male specimen the third joint is altogether red, perhaps not fully colored). Thorax and scutellum yellowish fulvous above, with golden hairs, mixed with black ones (in coloring and appearance the thorax resembles

that of *T. costalis*). Pleuræ and pectus grayish. Abdomen with yellow longitudinal line, expanding on the hind border of each segment, and thus forming a row of truncate triangles; on each side of this middle line there is a row of yellow spots, encircled in black; the size of the yellow spots goes on diminishing from the base to the tip; the yellow regions are clothed with a golden yellow pubescence; the black ones with a black pubescence; (the black varies in intensity in different specimens; in my male specimen it is very faint, the prevailing color of the abdomen being reddish yellow). Prevailing color of the venter yellow; in well preserved specimens with a delicate whitish pollen. Front legs: coxæ yellowish white with long, soft white hairs; trochanters brownish, femora brownish yellow or yellowish brown, with a gray pollen; tibiæ yellowish at the base, brownish on the latter half; tarsi brown. Middle and hind legs: femora brownish yellow, with a gray pollen, and with long, soft, whitish hairs; tibiæ yellow; first joint of tarsi yellow, brownish at tip; the following joints brown, yellow at the base. The hind tibiæ have a fringe of yellowish hairs, and are more or less tipped with blackish ones. Wings subhyaline, with but a very slight grayish tinge; costal cell tinged with yellowish; stigma yellow; the anterior branch of the third vein rather knee-shaped near its origin; first posterior cell broadly open. Length, 14–16 mm.

Hab. Middle States; Kentucky (Sanborn). A male and three females.

Observation. One of the female specimens before me differs from the others in its coloring. The face has a yellowish gray tinge, while in the other specimens the face is of a purer whitish gray; the pleuræ also are more yellowish gray instead of whitish gray; the palpi are decidedly yellow, with yellowish hairs on the stout, basal half, and with black hairs on the slender portion of the second joint, while in the other specimens they are whitish; the femora are black, with a gray pollen, their tips yellow. I do not doubt the specific identity of this specimen. The black design on the abdomen is sometimes very faint (for instance, in the male specimen before me).

This species has an unmistakable resemblance to *T. costalis* in its coloring; but it is considerably larger, the markings on the abdomen are altogether different, the costal cell is tinged with a less saturate yellow, the ♀ front is comparatively narrower; the first joint of the hind tarsi is yellow, brown at tip in *T. fulvulus* and altogether blackish in *T. costalis*.

27. Tabanus sagax n. sp.

Female. Face white, with white down; palpi rather stout, pale yellow, with short black hairs; antennæ bright orange red; third joint rather long, its annulate portion much shorter than the body of the joint, deep black; its upper angle very little projecting; front comparatively broad, nearly parallel, yellowish gray; callosity broad, brownish, irregular, nearly square, rounded on top; above it another, oblong, denuded spot. Thorax light gray, clothed with microscopic yellowish hairs; pleuræ and pectus whitish gray. Abdomen reddish, more brownish towards the end; a broad, conspicuous, whitish longitudinal stripe along the back, expanded at the incisures; on each side of the stripe a row of ill defined yellowish white spots, a pair on each segment, growing smaller towards the tip of the abdomen; venter yellowish red. Legs reddish yellow; tips of front tibiæ slightly infuscated; front tarsi and tips of the four posterior tarsi brown. Wings hyaline; veins yellowish; costal cell tinged with yellow; stigma saturate yellow. Length, 13–15 mm.

Hab. Illinois; Minnesota. Three females.

Not unlike *T. fulvulus* in the markings on the abdomen; but the markings, as well as the thorax, are grayish, instead of fulvous; the front is much broader, the frontal callosity larger; the third antennal joint is narrow, its upper angle but very little projecting; the dorsal stripe on the abdomen comparatively broader.

The eyes of *T. sagax* have a purple band between two green ones, above and below which there is, on each side, another less well defined, purple band.

28. Tabanus nigrescens.

Tabanus nigrescens Palisot-Beauvois, Ins., Dipt. Tab. II, f. 2; Wiedemann, Auss. Zw., I, p. 116, 6.

Male and female. Head of the male more convex than that of the female; large and small facets distinctly separated; frontal callosity (♀) much longer than broad, convex, black or dark brown, with a spindle-shaped prolongation above. Front grayish brown, brown in the middle; face brownish gray; cheeks with dark brown or black hairs; palpi black; antennæ black; base of the third joint red; its projecting angle almost rectangular. Thorax brown (of a more reddish brown in the female than in the male), with a faint grayish pollen anteriorly; no distinct stripes. Abdomen altogether black; legs black. Wings with a yellowish brown tinge, which is more saturate in the two basal cells; costal cell brownish (sometimes the wings have an altogether blackish tinge); stigma ferruginous brown; a blackish cloud on the crossvein between the discal and the second posterior cell, usually more or less extending over the crossvein next to it; a round, blackish cloud on the bifurcation of the third vein. Length, ♂, 20 mm.; ♀, 22–23 mm.

Hab. New York (Catskill Mountain House, July, 1874); Massachusetts; New Jersey; Pennsylvania; Maryland; Illinois; Knoxville, Tennessee; a specimen (♀) from Canada (Mr. W. Saunders) is smaller, and has very dark, almost blackish wings.

The eyes (♀) are dark and dull green, with three narrow purple bands, the upper one is distinct at the beginning only. The description of Palisot, brief as it is, cannot be doubtful in its interpretation, especially with the addition of the figure of the whole insect and its antennæ.

29. Tabanus punctifer n. sp.

Tabanus punctifer Loew in litt.

Male and female. Head (♂) large, with distinctly separated large and small facets; front (♀) broad (broader than in *T. nigrescens*); frontal tubercle large, somewhat ill defined in outline and rather flat; antennæ black, projecting angle of the third joint rectangular; face brownish; palpi black. Thorax and scutellum, above, whitish or yellowish white, in consequence of a dense pollen, covered by a pubescence of the same color; pleuræ, pectus, abdomen and legs black, or dark brown; front tibiæ white at the base for more than one third of their length. Wings brownish, especially on their proximal half; costal cell brown; a faint brown cloud on the crossvein at the base of the second posterior cell, which is not prolonged on the crossvein at the base of the third posterior cell; a dark brown round cloud at the bifurcation of the third vein. Length, ♂, 19 mm.; ♀, 19–20 mm.

Hab. West of the Rocky Mountains; Utah, Sonora, California, etc.; also Colorado (G. Ridings); seems to be a common species.

This species is not unlike *T. stygius* Say, but is a little smaller, and easily distinguished

by the white color of the base of the front tibiæ, the blackish or brownish, and not ferruginous brownish, wings, the absence of distinct white lines on the thorax, etc. The head of the male is much larger than in *T. nigrescens*, and the large facets occupy much more surface.

30. Tabanus stygius.

Tabanus stygius Say, Journ. Acad. Phil., III, p. 33, 3; Wiedemann, Auss. Zw., I, p. 131, 31.

Female. Frontal callosity much longer than broad, chestnut brown, with a spindle-shaped prolongation above. Front brown; a grayish spot on the vertex; face yellowish brown; palpi black; antennæ dark reddish brown, annulate portion of third joint often darker; third joint much excised, and the upper angle very salient. Thoracic dorsum (in well preserved specimens) clothed with a white pollen, through which the brown ground color is but little apparent; longitudinal white lines very distinct; a short white pubescence makes the dorsum appear still whiter. Pleuræ and pectus dark brown or blackish brown, in sharp contrast with the white thoracic dorsum. Abdomen black, subopaque; venter black or dark brown. Legs black or dark brown; front tibiæ slightly reddish at the base. Wings strongly tinged with ferruginous brownish; a brown spot on the bifurcation of the third vein, and a small cloud on the crossvein at the base of the second posterior cell, more or less prolonged on the next crossvein. Length, 20–22 mm.

Hab. Connecticut (Southington, July, W. H. Patten); Pennsylvania; Maryland (Am. Ent. Soc.); Illinois (Le Baron); Iowa (Dallas Co., Jefferson Co., J. A. Allen); South Carolina (Sea Islands, June 2d, B. P. Mann); Florida (in the spring, E. Palmer).

Say must have had a denuded specimen, as the characteristic white coloring of the thorax is not mentioned in his description; Wiedemann's is more explicit. The eyes (as far as I saw them on an alcoholic specimen from Florida) are dark green with two dark purplish bands and the vestige of a third above; therefore similar to the eyes of *T. nigrescens*.

31. Tabanus atratus.

Tabanus atratus Fabricius, Syst. Entom., p. 789, 9; Entom. Syst., IV, p. 366, 16; Syst. Antl., p. 96, 16; Wiedemann, Dipt. Exot., I, p. 63, 2; Auss. Zw., I, p. 114, 3.—Macquart, Dipt. Exot., I, 1, p. 142, 41; Bellardi, Saggio, I, p. 58. — Harris, Ins. N. Engl., 3d Edit., p. 602.

Tabanus niger Palisot-Beauvois, Ins., Dipt. Tab. I, f. 1.

Tabanus americanus Drury Ins., I, Tab. 44, f. 3.

Tabanus validus Wiedemann, Auss. Zw., I, p. 113, 2.

Male and female. Altogether black; head of the male large, subhemispherical, the large facets occupying an extended area, distinctly separated from that of the small facets; front (♀) unusually broad; callosity broader than long; subcallus denuded, shining; third antennal joint deeply excised, its upper corner very salient, pointing forward, its narrow portion remarkably long, gradually merging into the annulate tip; front tibiæ whitish at base, hind tibiæ with a fringe of black hair; abdomen usually with a bluish white efflorescence; wings black or brown; first posterior cell strongly coarctate, often altogether closed. Length, ordinary specimens, 20–26 mm.; small ones down to 16 mm.

Hab. United States, common. I have specimens from Quebec, Can., Maine, Massachusetts, where it is not rare (Cambridge, Nahant, Chelsea Beach), District of Columbia, Maryland, Indiana, Kentucky, Florida, Kansas, Nebraska, Texas. Bellardi had it from Mexico.

This species varies in appearance very much. Northern specimens, for instance those found round Boston, often have the wings pale brown, even yellowish brown, towards the posterior margin. The most remarkable variety, however, I received from Florida (Indian River, E. Palmer; Haulover Beach, March 12–14, Messrs. Hubbard and Schwarz); the thorax on each side bears a fringe of golden yellow hairs, not a trace of which is visible in ordinary specimens. I have four specimens from Florida, and two from some other southern locality not nearer defined, which show this peculiarity. A very small specimen from Key West (Feb. 7, 1869, in Mr. E. Burgess' collection) has none of these hairs. The very broad front, broad frontal callus, shining subcallus and coarctate first posterior cell, prove, I think, the specific identity of all these varieties.

The *T. validus* Wiedemann is, to all appearance, based upon a brownish or reddish colored specimen of *T. atratus*. Drury's name, *T. americanus* (1773), although the oldest, cannot have the priority on account of *T. americanus* Förster (1771), which is *T. rufi-cornis* Fab.

The eyes of *T. atratus*, according to Dr. Harris (Ins. Inj. to Veget., 3d Edit., p. 602), "are of a shining purple black or bronzed black color, with a narrow jet black band across the middle, and a broad band of the same hue on the lower part." I have revived, on wet sand, the eyes of specimens from Texas and from Massachusetts (with the yellowish hind border of the wing), and have found them to agree with this description.

32. Tabanus Wiedemanni.

Tabanus ater Wiedemann (non Palisot-Beauv.) Auss. Zweifl., I, p. 136, 39 (ex parte; non Dipt. Exot.).

Female. Altogether black, with a slight brownish pollen on the thorax, grayish in front. Face and front also with a brownish pollen; antennæ black, upper angle of third joint very salient; the basal portion of this joint rather broad; annulate portion not longer than the basal portion. Frontal callus square, black, shining, prolonged upwards as a black, shining stripe, not quite reaching the vertex, and nearly as broad as the callus, leaving but a narrow strip of the brownish front on each side; subcallus less shining, somewhat denuded. Wings dark brown; a still darker brown cloud on the bifurcation of the third vein; first basal cell perceptibly coarctate. Length, 16 mm.

Hab. Enterprise, Florida, May 17, 1875. Messrs. Hubbard and Schwarz.

Wiedemann described *T. ater* for his Diptera Exotica from Westermann's collection in Copenhagen. Later, when writing his "Aussereurop. Zweifl. Ins.," he identified a specimen of the Vienna Museum with his earlier description (without having the original specimens before him), but added: "It agrees very well with my description, only the coloring, especially of the abdomen, is more blackish brown than deep black. The front is very smooth, has a transverse subcallus and *above it a broad, smooth stripe, running towards the vertex.*" This addition, and especially the last character, proves, to my mind, that Wiedemann had the present species before him; but whether his former description refers to the same species, seems doubtful to me. In several details (very small tooth of the third antennal joint, front shining black, very convex front behind the antennæ) that description points to *T. lugubris*; only the size of the female, seven lines, is too large for it. At any rate, the name *T. ater* cannot be used, on account of the much older *T. ater* Rossi (1790).

T. Wiedemanni is easily distinguished from *T. atratus* by its smaller size, much narrower front, the shape of the callosity and of the stripe above it, the shape of the third antennal joint, which is much less excised, the brown cloud on the bifurcation of the third vein and the less coarctate first posterior cell.

From *T. lugubris* the present species differs in its somewhat larger size, its less shining surface, in the structure of the antennæ, the shape of the callosity with prolongation, the less convex subcallus and the cloud on the bifurcation of the third vein.

33. Tabanus lugubris.

Tabanus lugubris Macquart, Dipt. Exot., I, 1, p. 145, 48.

Tabanus ater Palisot-Beauvois, Ins., Dipt. Tab. II, f. 5.—Wiedemann, Dipt. Exot., I, p. 74, 23; Auss. Zw., I, p. 136, 39 (ex parte).

Female. Antennæ black; third joint long; annulate portion especially elongate; body of the joint comparatively small, its upper angle well marked, nearly rectangular, but not drawn out. Face and cheeks black, shining, with a little brownish pollen in the middle of the former, between the furrow; palpi deep black. Front black, shining, some traces of a grayish pollen visible on the sides, above the callosity; the latter large, convex; subcallus also very convex, black, shining. Thorax and abdomen black, shining, with a thin brownish pollen; thorax in front with some grayish pollen. Legs black. Wings uniformly black; first posterior cell perceptibly coarctate. Length, 13–14 mm.

Hab. Carolina (Macquart); Sea Islands, South Carolina, June 2d (B. P. Mann). A single female.

The shape of the third antennal joint of this species is characteristic; unfortunately, Macquart could not describe it, as it was wanting in his specimen. Nevertheless, the description leaves but little doubt about the identification.

Palisot's short description and figure seem to refer to this species rather than to *T. Wiedemanni*. Compare especially the side view of the very convex subcallus. Moreover, it is not probable that Palisot, in the then existing state of descriptive entomology, would have distinguished *T. Wiedemanni*; he would have probably taken it for a small *T. atratus*, the resemblance between the two species being very great. About Wiedemann's interpretation compare the observation at the end of the description of *T. Wiedemanni*. As there is a much older *T. ater* Rossi (Fauna Etrusca, 1790), Macquart's name must be adopted.

34. Tabanus rufus.

Tabanus rufus Palisot-Beauvois, Ins., Dipt. Tab. II, f. 1, p. 100. — Wiedemann, Auss. Zw., I, p. 117, 8 (merely a translation of Palisot's description).

Tabanus fumipennis Wiedemann, Auss. Zw., I, p. 119, 11.

Female. Face reddish yellow; palpi rather long and slender, reddish; front rather broad, parallel, yellowish brown; callosity not longer than broad, chestnut brown, or dark brown, with a spindle-shaped prolongation above. Antennæ pale red, third joint much excised, its upper angle very salient and slightly drawn out forward. Thorax more or less brown above, with a delicate grayish pollen and faint reddish lines, more reddish on the sides; pleuræ and pectus yellowish, with yellowish hair. Abdomen ferruginous reddish, with a longitudinal blackish stripe, which expands posteriorly and occupies nearly the whole

dorsal surface of the three last segments. Legs yellowish red; front tarsi brownish. Wings strongly infuscated; a distinct brown cloud on the bifurcation of the third vein, a very faint one on the crossvein at the base of the second posterior cell. Length, about 23 mm.

Hab. Savannah, Georgia (Wiedemann); Florida (Lake Harney, May 4, Messrs. Hubbard and Schwarz); S. Carolina (Sea Islands, June 2, B. P. Mann). I have four females.

The cloud on the bifurcation of the third vein is not mentioned by Wiedemann; it nevertheless exists in his original specimen in the Vienna Museum (as Dr. Redtenbacher kindly informs me). The eyes of this species (as I saw them on an alcoholic specimen) have three narrow bluish stripes, not reaching the external border; the ground color of the eye was reddish green.

35. Tabanus Megerlei.

Tabanus Megerlei Wiedemann, Aus. Zw., I, p. 132, 32.

Female. [Antennæ brown, root of the third joint ferruginous yellow, with a strong tooth; face brown, somewhat yellowish on the sides; cheeks and palpi brown; beard black; front yellowish white below, lighter in the middle, the upper part yellowish.] Callosity nearly square, brown or black, convex. Thorax blackish, reddish on each side, with whitish lines on the dorsum; pleuræ brown, with black hair. Abdomen reddish, with a broad black stripe in the middle, which is somewhat narrower on the second and third segments; a whitish pollen and a golden yellow pubescence clothe the red portions of the abdomen; lateral margins blackish, fringed with black hair. Venter reddish. Wings brownish on the proximal half, especially along the veins; crossveins and bifurcation of the third vein with dark brown clouds. Length, 17–18 mm.

Hab. Florida (caught by myself on St. John's River in March, 1858). A single female.

T. Megerlei is described by Wiedemann without indication of locality. My specimen agrees perfectly with his description. At present this specimen is somewhat injured about the head, so that I am compelled to translate from Wiedemann the portion of my description enclosed in brackets. The black fringe of hair along the edges of the otherwise red abdomen of this species cannot well be mistaken. In the present condition of my specimen I cannot well ascertain whether its eyes are pubescent or fulvous, and whether it has an ocellar tubercle or not.

36. Tabanus americanus.

Tabanus americanus Förster, Nov. Spec. Centur., I, 100.

Tabanus plumbeus Drury, Ins. I, Tab. 44, f. 2.

Tabanus ruficornis Fabricius, Syst. Ent., p. 789, 8; Ent. Syst., IV, p. 365, 14; Syst. Antl., p. 96, 14.—Wiedemann, Dipt. Exot., I, 62; Auss. Zw., I, p. 112, 1.

Tabanus limbatus Palisot-Beauvois, Ins., Dipt. Tab. I, f. 2.

Female. Dark violet brown ("*obscure coccinelleus*" of Wiedemann) sometimes more reddish. Face grayish, with gray hair; front grayish; antennæ red; in some specimens the annulate portion is brown; third joint deeply excised; its upper angle drawn out, as a pointed horn; frontal callus chestnut brown, prolonged in a line above; palpi brownish red, with dense, short black hairs. Thorax with a whitish efflorescence, hardly concealing the dark ground color; a tuft of white hairs between the root of the wings and the scutellum.

Pleuræ with a whitish down and with longer white hairs, especially between the root of the wings and the base of the abdomen; abdomen covered with a thin whitish efflorescence, not concealing the ground color, but visible in an oblique light; it is more perceptible along the hind margins of the segments, where, on each side, it becomes broader and very distinct; hind margins of the ventral segments also whitish. Legs brownish red, tarsi darker; hind tibiæ with fringes of dark hairs. Wings hyaline, costal cell and stigma infuscated; first posterior cell somewhat coarctate.

Male. Head large, subhemispherical, like that of *T. atratus* in shape; the large facets occupy a very extended area, and are distinctly separated from the small ones. Hairs on head and chest more yellow than in the female. (I have only a single specimen, from Florida, before me.) Length, 25–30 mm.

Hab. Middle and Southern States. I have seen specimens from Illinois; Sea Islands, S. C.; Florida (Ft. Capron, Fla., April 25, Messrs. Hubbard and Schwarz); Kentucky; Missouri; Pennsylvania; Detroit, Mich. (Mr. Hubbard). From Mr. Akhurst I received a specimen caught in the State of New York.

Förster's name, being the oldest (1771), should have the priority. Drury's description and figure are older, but the name *T. plumbeus* Drury, appears only in Vol. II, Appendix (1773). Förster is wrong in quoting Drury's figures, 2 and 3; the latter is *T. americanus* Drury (Syn. *atratus* Fab.). This is the largest of the North American Tabani, and seems to be very common in some parts of the south and west. The eyes are unicolorous, of a brilliant green.

37. Tabanus giganteus.

Tabanus giganteus DeGeer, Ins., VI, p. 226, 1; Tab. XXX, f. 1.

Tabanus lineatus Fabricius, Spec. Ins., II, p. 455, 4; Entomologia System., IV, p. 363, 5; Syst. Antl., p. 94, 3.—Wiedemann, Dipt. Exot., I, p. 63, 3; Auss. Zw., I, p. 115, 4.

? Tabanus bicolor Macquart, Dipt. Exot., 2e Suppl., p. 34, 129 (♀).

? Tabanus cæsiofasciatus Macquart, Dipt. Exot., 5e Suppl., p. 32, 126 (♂).

Female. Front rather narrow, grayish; frontal callus chestnut brown, prolonged upwards as a narrow, smooth line; face whitish yellow or yellowish white; palpi reddish yellow, beset with golden yellow and black hairs. Antennæ red, third joint deeply excised, upper angle projecting, horn-like. Thorax brownish above, more or less clothed with grayish pollen, with indistinct darker stripes and reddish lines between them; scutellum usually reddish, with a black spot at the base. Pleuræ and pectus clothed with yellowish or whitish hairs. Abdomen blackish, more or less covered with a white efflorescence; the sides of the abdomen, especially on the second segment, reddish; incisures more or less whitish. Legs brownish red; tarsi darker; hind tibiæ with a fringe of black hair. Wings tinged with pale brown; costal cell and stigma ferruginous brownish; first posterior cell but slightly coarctate. Length, 22–25 mm.

Hab. Middle and Southern States. I have seen specimens from Connecticut (Suffield, G. Dimmock), Pennsylvania, Illinois, Missouri, Arkansas, Sonora. Dr. Harris's Catalogue quotes this species from Massachusetts.

The eyes of this species are unicolorous. DeGeer's *T. giganteus* is evidently this species; about the confusion existing between it and *T. calens* Linné, see Wiedemann, Auss. Zw., I, p. 135.

I do not see any thing in Macquart's description of *T. bicolor*, which would prevent the interpretation I give it. Anyhow, the name cannot stand, as there is an earlier *bicolor* by Wiedemann. Observe at the same time that Macquart does not mention *T. lineatus* anywhere in his works.

In Mr. C. V. Riley's collection I find a very much damaged specimen, which I take to be the male of this species, the only one I have seen. The head is flattened above, and not very large. The demarcation between the large and small facets of the eye is distinct, although the large facets are comparatively smaller than in the allied species. Macquart says of his *T. cæsiofasciatus* ♂ : "Yeux nus, composés entièrement de fort petites facettes," which rather confirms me in the belief that this is the male of *T. giganteus*.

38. Tabanus mexicanus.

Tabanus mexicanus Linné, Syst. Nat., II, p. 1000, 10.—Fabricius, Spec. Ins., II, p. 457, 16; Ent. Syst., IV, p. 367, 22; Syst. Antl., p. 98, 25.—Wiedemann, Dipt. Exot., I, p. 76, 29; Auss. Zw., I, p. 147, 58.—Macquart, Dipt. Exot., I, 1, p. 143, 43.

Tabanus punctatus Fabricius, Ent. Syst., IV, p. 368, 25.

Tabanus inanis Fabricius, l. c., 26.

Tabanus ochroleucus Meigen, System. Beschr., II, p. 62, 41. (Meigen erroneously took it for European.)

Tabanus olivaceus DeGeer, VI, p. 230, 6; Tab. 30, f. 6. (DeGeer quotes Linné.)

Tabanus sulphureus Palisot-Beauvois, Ins., p. 222, Dipt. Tab. III, f. 3.

Tabanus flavus Macquart, Hist. Nat. Dipt., I, p. 200. 13; Guérin et Percheron, Genera, etc., Dipt. Tab. II.

Tabanus viridiflavus Walker, Newman's Zool., VIII, App. lxvi ("fide Walker," thus quoted by Bellardi, Saggio, I, p. 59).

The whole body is pale yellowish, more or less tinged with greenish; palpi yellow, slightly incrassated at the base of the second joint; antennæ of the same color, sometimes green; upper angle of the third joint projecting, rectangular; front nearly parallel, without any callosity; the head of the female being large, the front, for a *Tabanus*, has an unusual length. Thorax densely clothed with yellow hairs. Wings subhyaline, sometimes slightly tinged with yellowish; costal cell and stigma yellow; crossveins and bifurcation of the third vein usually (not always) clouded with brown; according to Wiedemann, brown clouds sometimes also occur on the tips of the veins, along the margin; but this probably applies to the South American species, which he had before him. All my specimens have a stump of a vein on the bifurcation of the third vein.

Hab. Florida; South Carolina (Sea Islands, May 17, 1869, B. P. Mann); New Jersey (Am. Entom. Soc.); Missouri (Riley); Mexico (Bellardi); South America (Wiedemann).

I never saw this species alive, but believe that in that state the green color must be more distinct; in dry specimens only traces of it remain, very irregularly distributed over the body. The synonomy of Fabricius's names I borrow from Wiedemann, who saw the original types; the same for Meigen's *ochroleucus*.

About his *T. flavus* Macquart says that the type is in Percheron's cabinet; Percheron's figure deserves, therefore, full credit. It is strange, nevertheless, that while Macquart expressly mentions the absence of the stump on the fork of the third vein, Percheron figures this stump as very long; Macquart mentions a dark spot at the base of the fork, Percheron neither figures nor mentions it! I do not know how to explain these contradictions in the face of a synonymy which cannot be doubted.

Palisot's figure of the front of his *T. sulphureus* shows the absence of the callosity, and thus unmistakably points to *T. mexicanus*.

B. Tabani with pubescent eyes, but without ocellar tubercle.

39. Tabanus bicolor.

Tabanus bicolor Wiedemann, Dipt. Exot., I, p. 96, 58; Auss. Zw., I, p. 188, 115; *male.*
Tabanus ruficeps Macquart, Dipt. Exot., 5e Suppl., p. 35, 130; *male.*

Female. Eyes pubescent; head comparatively broad; face pale yellowish; palpi short and turgid, yellowish, with sparse, black hairs; front and vertex yellowish; no frontal callosity; antennæ reddish yellow, third joint remarkably broad and comparatively short. Thorax brownish yellow, in consequence of the dense pollen which conceals the brownish olivaceous ground color; the pleuræ somewhat grayish. Legs reddish yellow. Abdomen reddish on the sides, yellowish brown in the middle and at the tip (the latter color being the effect of a brown ground color covered with brownish fulvous pollen and fulvous hairs). Wings hyaline; veins yellow.

Male. Head large, but not flattened on top; large and small facets distinctly separated; thorax somewhat more yellowish than in the female, the yellow hair upon it being more dense. Abdomen reddish yellow, with a dark longitudinal stripe, which is narrowest in the middle, but varies in breadth in different specimens. Length, 10–11 mm.

Hab. New York; Pennsylvania; Illinois; Canada. I have three male and two female specimens before me.

The male of this species is more frequently met with in collections than the female. Although Macquart says "yeux nus" of his *T. ruficeps*, I have not the slightest doubt that it is the same as *T. bicolor* Wied.

40. Tabanus fulvescens.

Tabanus fulvescens Walker, List, etc., I, p. 171.

"*Mas.* Fuscus, capite flavo-albido, thorace fusco, pectore cano, abdomine fulvo, fusco nonnunquam vittato, pedibus flavis, alis limpidis.

"Head yellowish white, clothed beneath with white hairs; feelers and palpi yellow; eyes red; chest pale brown, clothed with tawny hairs: breast hoary, clothed with white hairs; abdomen tawny, slightly clothed with tawny hairs, and having a broad grayish brown stripe, which appears only at the base of the underside; legs yellow; wings colorless; wing ribs and veins tawny, the latter piceous towards the tip; poisers yellow.

"Length of the body, 4½ lines (11–12 mm.); of the wings, 9 lines.

"*a.* Massachusetts. From Prof. Sheppard's collection.

"*b.* ———?

"Var. Abdomen not striped."

I have two specimens (male and female) from Canada (Quebec, Mr. Belanger, and Portneuf, Mr. Provancher) which agree quite well with this description, except that, in the male, the brown longitudinal stripe runs along the whole venter, and that the tarsi are infuscated at the tips. The body of the female is darker; the tips of the front tibiæ are infuscated; the front tarsi are brown, except at the base.

This species (if it be distinct) resembles *T. bicolor* very much in its general appearance, in the absence of a frontal callosity, in the pubescence of the eyes, etc. It is easily distinguished, however, by the whitish gray color of pectus, pleuræ and front coxæ, which color also appears on the cheeks and around the mouth. The third joint of the antennæ (in my two specimens at least) is slightly narrower; the general coloring of the body, especially in the female, is darker.

41. Tabanus Reinwardtii.

Tabanus Reinwardtii Wiedemann, Auss. Zw., I, p. 130, 30.
Tabanus erythrotelus Walker, Ins. Saunders, p. 25; Tab. II, f. 1.

Female. Front rather broad, grayish, with a well marked brown crossband in the middle and a dark spot on the vertex; frontal callosity large, nearly square, brown, prolonged as a line above; face and cheeks white, with white hair; palpi moderately stout, yellow, with a grayish pollen, and short black hairs; antennæ: first and second joints reddish (in some specimens almost black), with black hair; the third black, red at base; upper angle well marked, projecting, nearly rectangular. Thorax grayish slate color, sometimes more blackish; more or less reddish on the sides and along the suture; the usual gray stripes are well marked and beset with whitish hairs in well preserved specimens. Pleuræ and pectus whitish, beset with white hairs; on the pleuræ a faint reddish ground color is often apparent; a fringe of black pile between the root of the wings and the humerus. Abdomen grayish slate color, usually faintly reddish on the sides; an intermediate row of triangular and lateral rows of oblique whitish spots; hind margins of segments fringed with short white hairs. Venter densely clothed with white pollen and short white hairs, the latter especially on the hind margins of segments, the ground color being blackish, or pale reddish. Legs pale reddish or yellowish, clothed with grayish pollen and white hairs; tarsi nearly black; all the tibiæ blackish at tip, front tibiæ up to their middle, (in some specimens the femora, especially the front femora, are darker). Wings subhyaline; central crossveins, crossveins at the end of the discal cell, and bifurcation of the third vein, distinctly clouded with brown; front posterior cell very slightly coarctate.

Male. Antennæ usually black, except the extreme root of third joint; face and cheeks grayish, with blackish hair; legs darker, femora nearly black; thorax blackish, with dense blackish and gray pile; antealar callus reddish; abdominal markings much less well defined; white hairs on the abdomen longer; brown clouds on the wings less well marked. The line between the large and small facets on the eyes well defined, although the large facets are comparatively smaller than in other species. (In life a single green stripe on purple ground on the lower part of the eyes.) Length somewhat variable, the usual size 16–18 mm.; sometimes only 14 mm. My male specimens measure about 16 mm.

The eyes are pubescent in both sexes; very distinctly in the male.

Hab. Canada (Bélanger, Provancher, Couper); Iowa (Jefferson and Dallas Counties, J. A. Allen); Illinois; Vermont (Bridgport, Miss A. M. Edmands); Virginia; Pennsylvania (Am. Ent. Soc.). I have ten female and three male specimens.

The description of the legs of *T. erythrotelus* Walker does not agree with this species; but Westwood's figure which is appended, the locality (Bolton, N. Amer.), and the non-

existence of any other species with which to identify the description, render the synonymy certain. In this species the ocellar tubercle is not visible; the pubescence of the eyes in the male is very distinct; in the female very short, and often hardly visible. The coloration of the eyes of the female (revived on wet sand) appeared not unlike that of *T. trijunctus, catenatus*, and that whole group: two bluish green stripes, with a rather broad interval; the lower stripe bent towards the upper one at the outer end, without, however, reaching it.

42. Tabanus cerastes n. sp.

Female. Eyes pubescent; face white, with white hair; palpi rather stout, pale yellow, with white, mixed with a few black hairs; antennæ reddish, third joint very deeply excised, almost crescent-shaped, upper angle drawn out in a rather long horn, which, as well as the annulate portion of the third joint, is black; sometimes the whole joint, except the base, is brownish; front moderately broad, grayish yellow; callosity brownish red, large, square; a spindle-shaped brown line above it is usually disconnected from it; (in my three specimens this line has a well marked groove in the middle, which ends in a deep puncture on the callosity; this may be a merely adventitious character of the species). Thorax of a light chocolate brown with whitish lines; pleuræ whitish, with white hair. Abdomen of a light chocolate brown, with white triangles in the middle, and rather large, oblique, white spots on the sides. Venter densely clothed with whitish pollen, and with a trace of a longitudinal brown stripe. Feet reddish, whitish pollinose, and with white hairs; tips of tibiæ and all the tarsi brown. Wings subhyaline, faintly tinged with brownish between the root and the stigma; first posterior cell broadly open. Length, 15–16 mm.

Hab. Kentucky (Bee Spring, June. F. G. Sanborn); Wisconsin (R. Kennicott).

The long horn-like upper angle of the antennæ, as well as the peculiar brown coloring, renders this species easily recognizable. *T. scitus* Walker seems to have antennæ of the same structure; in other respects its description is entirely unmeaning. The words "antennes à dent un peu allongée," in Macquart's description of his *T. hirtiocalatus* ♂ (Dipt. Exot., 5e Suppl., p. 33), together with the pubescent eyes, may indicate the unknown male of my *T. cerastes*; still the data of the description are not sufficient to warrant the identification of the female. The eyes of an alcoholic female showed a single bluish stripe in the middle.

C. Tabani with pubescent eyes and with an ocellar tubercle (subgenus *Therioplectes*).

43. Tabanus flavipes.

Tabanus flavipes Wiedemann, I, p. 137, 41.

Female. Eyes pubescent, face yellowish gray, with dense yellow hair on the cheeks; some blackish hairs below the eyes; palpi long and narrow, black. Antennæ dark red; third joint black on its distal half, excised above, and with a projecting upper angle; front rather broad, narrowed anteriorly, dark grayish; callosity very convex, with a more or less spindle-shaped prolongation above; the subcallus in all my specimens is denuded, shining. Thorax black, with black, erect pile, mixed with yellowish hairs, especially in front; antealar tubercle black; pleuræ black, clothed with sparse yellowish hairs, which are denser

under the wings. Abdomen black, thinly clothed with pale golden yellow hairs, which are more dense along the hind margins of the segments, where they form narrow, but conspicuous pale golden yellow fringes. Venter black; hind margins of segments likewise fringed with pale yellow hairs. Front femora black, reddish at tip; front tibiæ reddish yellow, blackish at tip; front tarsi black; four posterior femora black on the proximal half only; the remainder, as well as the tibiæ and tarsi, reddish yellow. Wings tinged with brownish, brownish ferruginous along the costa. Length, 14–17 mm.

Hab. Labrador (Dumplin Harbor, July 19, common, A. S. Packard). Wiedemann's specimens were from the same country. I have six females.

Among Mr. Packard's specimens from Straits of Belle Isle, I find a male, which apparently belongs here. The sides of the second abdominal segment are reddish. The head is moderately large, and the difference between the large and small facets well marked, although not very considerable.

According to Wiedemann, this species is very like the European *T. auripilus* Meig.

There is a superficial resemblance between this species and *T. zonalis*; they are easily distinguished, however, by the much broader yellow borders of the abdominal segments and the reddish antealar tubercles of *T. zonalis*. The front of *T. flavipes* is broader, the palpi narrower, etc.

44. Tabanus zonalis.

Tabanus zonalis Kirby, Fauna Boreali-Americana, IV, p. 314, 2.
Tabanus tarandi Walker, List, etc., I, p. 156; *female*.
Tabanus terræ novæ Macquart, Dipt. Exot., 4e Suppl., p. 39, 109.

Female. Eyes pubescent; third joint of antennæ red, more or less black at tip (sometimes the annulate portion alone is black, sometimes this color extends beyond it), distinctly excised above, with a projecting upper angle; face and front clothed with a golden yellow (in some cases whitish yellow) pollen; cheeks with fulvous and black hairs; frontal callosity black, nearly square, with a spindle-shaped, often disconnected line above; vertex black; palpi brown, densely clothed with black hair. Thorax black, antealar tubercle reddish. Abdomen black, hind margin of all segments with a broad yellow border, formed by yellow pollen, clothed with golden yellow hairs; on the second, and sometimes on the third segments, this border has, anteriorly, a shallow excision, bounded on each side by a pointed projection; venter black, the hind margins of the segments also bordered with yellow. Femora black, reddish at the tip; tibiæ and tarsi reddish yellow; front tibiæ at the tip, and front tarsi, black; hind tibiæ with a distinct fringe of reddish hair. Wings tinged with brownish; ferruginous brownish along the costa. Length, 17–18 mm.

Hab. Has a wide distribution in the northern regions of North America; Maine (Fernal); northwestern parts of the Hudson's Bay Territory (R. Kennicott); Saskatchewan River (Scudder); Washington Territory (G. Gibbs); Labrador (Packard); Canada (Quebec, Bélanger); Anticosti (Verrill); St. Martin's Falls, Albany River, Hudson's Bay (Walker); Newfoundland (Walker and Macquart). I compare twenty-four female specimens.

In old and worn specimens the yellow portions of the body appear more whitish. The typical specimen described by Kirby must have been in that condition, as appears from his description. The mention of the reddish antealar callosity, as well as the measurement

(7½ lines) given by Kirby, prove that he meant the above described species, and not *T. flavipes*. The eyes of the female (revived on wet sand) showed four dull green stripes, the upper and lower one not defined on the outside, very like the eyes of *T. cinctus*.

45. Tabanus cinctus.

Tabanus cinctus Fabricius, Ent. Syst., IV, p. 366, 18; Syst. Antl., p. 97, 20; Meigen, Syst. Beschr., etc., II, p. 42, 16 (where this species is erroneously quoted as European, an error corrected afterwards in the preface to the third volume).— Wiedemann, Dipt. Exot., I, p. 67, 10; Auss. Zw., I, 119, 12.— Harris, Ins. New Engl., 3d Edit., p. 602, fig. 261.

Male and female. Eyes pubescent; face brownish gray, beset on the cheeks with blackish hair; palpi black, or dark brown; front (♀) yellowish brown; callosity chestnut brown, square or semi-oval, with a black, irregular prolongation above; ocellar tubercle very distinct. Thorax black, somewhat shining, beset with black hair. First three segments of the abdomen yellowish red, beset with fulvous hair; an inverted black triangle rests with its base against the scutellum, and occupies with its apex the middle of the second segment; remaining segments of the abdomen deep black. Legs black. Wings brownish. Length, 18–19 mm.

Hab. Massachusetts; White Mountains, N. H. (H. K. Morrison); Connecticut (Southington, in July, W. H. Patton); Pennsylvania; Maryland (Am. Entom. Soc.); Georgia (J. Ridings); Virginia (Wiedem.). Mexico [?] (Walker, List, etc., I, p. 153).

In the male of this species the difference between the large and small facets of the eyes is hardly perceptible, and the line of demarcation between them is indistinct (at least in dry specimens). The eyes of the female show four dull green stripes, the upper and lower ones of which are not distinctly defined on the outside. The pubescence on them is very difficult to ascertain. This seems to be closely related to *T. trispilus*.

46. Tabanus trispilus.

Tabanus trispilus Wiedemann, Auss. Zw., I, p. 150, 62.

Female. Face yellowish gray, with yellowish hairs on the cheeks; palpi yellowish, beset with short, black hair; front gray; callus black, semi-oval, prolonged above in a somewhat spindle-shaped line; ocellar tubercle very distinct, reddish; antennæ red, first joint with gray pollen; the third joint black on its distal end, broad, with a salient upper angle and a shallow excision. Thorax blackish gray, with two faint longitudinal gray stripes and a gray line between them; under the lens these gray stripes appear beset with minute fulvous hair; antealar tubercles reddish; pleuræ gray, beset with pale yellowish, whitish and black hair. Abdomen grayish black (dark slate color), darker than the thorax; hind margins of segments with a narrow whitish border, beset with a fringe of whitish hairs; in the middle of this border, on segments two to five, a very distinctly defined white triangle, occupying the whole breadth of the segment; that on segment two is the largest, this segment being the broadest; that on segment five is very small, often almost obsolete; there is also a small whitish spot in the middle of the first segment, under the scutellum; the lateral margins of the abdomen are whitish, and beset with white hairs. Venter whit-

ish gray, with a broad blackish longitudinal stripe in the middle. Legs black; proximal half of the tibiæ more or less reddish brown. Wings tinged with brownish gray; a shade of brownish runs from the stigma across the central crossveins; costal and basal cells also with a faint brownish tinge; first posterior cell open.

Male. Much darker in coloring than the female. Head of moderate size; the demarcation between the large and small facets is hardly visible, as these facets differ in size but very little. Thorax black, beset with black hair; anteriorly some grayish pollen and yellowish hair; longitudinal stripes obsolete; antealar tubercle dark reddish; pleuræ beset with yellowish hairs, and with blackish ones in the middle; abdomen black, often dark brown on the sides of the second and third segments; white triangles on segments two and three very distinct, silvery white, that on segment four smaller, often subobsolete; the hind margins of the segments have no fringe of white hair, but a narrow border of whitish pollen is visible in a certain light. Venter black or brown; hind margins of segments white. Wings with a brownish tinge, somewhat more saturate than in the female. Length, 14–15 mm.

Hab. New England (Cambridge, Mass., in July, White Mountains, July 13. S. H. Scudder; Southington, Conn., July, W. H. Patton); Illinois; New York; also Middle States (Am. Ent. Soc.). I have three males and seven females before me.

The eyes are pubescent; in the female, however, the pubescence is very difficult to perceive. The eyes of the female show four bright green stripes, with purple intervals of nearly the same breadth.

I had some doubts about the identification of this species with the *T. trispilus* of Wiedemann; first, because he does not mention that the eyes are pubescent, although he had a male specimen, in which his pubescence is usually very distinct; secondly, because he calls the pubescence on the cheeks *brownish*, while it is yellowish gray. Through Dr. Redtenbacher's kindness I have been able to remove these doubts. He has caused Wiedemann's type in the Vienna Museum to be examined, and informs me that it has distinctly pubescent eyes, and that the hairs on the cheeks are grayish, and not brownish.

47. Tabanus lasiophthalmus.

Tabanus lasiophthalmus Macquart, Dipt. Exot., I, 1, p. 143, 45.
Tabanus notabilis Walker, List., etc., I, p. 166.

Female. Eyes pubescent; face yellowish white, with hair of the same color; palpi rather stout, whitish yellow, with white and more or less black hair; front rather broad, slightly converging anteriorly, yellowish gray, mixed with brown, and with short black pile; frontal callosity black; below it the subcallus is usually bare, black, shining; above the callosity a small, denuded blackish spot, usually disconnected from it, and surrounded with a brownish shade; ocellar tubercle very distinct, a brownish shade around it; antennæ reddish, more or less black at the tip of the third joint, the latter with a projecting, nearly rectangular, upper angle. Thorax grayish black, with a shade of brown; the usual longitudinal grayish lines, in well preserved specimens, are beset with fulvous hair; antealar tubercle somewhat reddish; pleuræ gray, with whitish hair. Abdomen brownish black in the middle, yellowish or reddish brown on the sides; large oblique yellowish white lateral

spots on each segment, gradually diminishing and becoming more rounded posteriorly; at the middle of the hind margin of the segments a small fringe of yellowish hair, sometimes assuming a subtriangular shape. Venter yellowish, often more or less blackish, clothed with a thin grayish pollen and yellowish hairs. Legs yellowish red, base of femora, to a greater or less extent, black; tarsi black, except the base of the four posterior ones, which is reddish; tips of front tibiæ blackish. Wings hyaline; crossveins and bifurcation of the third vein clouded with brown; first posterior cell broadly open.

Male. Face dark grayish, beset with blackish hair; antennæ darker; third joint more narrow; thorax clothed with denser blackish pile, gray lines less distinct; legs black, tibiæ and base of four posterior tarsi reddish brown. Length, 12–16 mm., both sexes being rather variable in size.

Hab. United States and British Possessions; not rare. (Massachusetts; Maine; Detroit, Mich.; Illinois; Quebec, Canada, etc.)

I have seen Walker's *T. notabilis* in the British Museum.

48. Tabanus affinis.

Tabanus affinis Kirby, Fauna Bor.-Amer., IV, p. 313, 1.

Female. Eyes pubescent; palpi brownish yellow, with short black hairs; second joint moderately stout at base; face yellowish gray; antennæ dark red, third joint black on its latter half, its basal portion rather broad, the upper angle projecting and the excision well marked; front dark yellowish gray, somewhat convergent anteriorly, clothed with black hair; callosity black (seldom reddish), rather small for the size of the species, with a usually spindle-shaped prolongation; ocellar tubercle brownish black, very distinct. Thorax dark grayish black with a tinge of brownish, and with more or less distinct gray lines; antealar tubercles reddish. Sides of the first four abdominal segments rufous, which color leaves a black stripe in the middle, narrowest on the second segment, and expanding on the third and fourth (in some specimens the fourth segment is almost black, with only a rounded reddish spot on each side; in others the red color invades even the fifth segment); on each of the segments two to five, on the black stripe, there is a triangular whitish yellow spot (formed by pollen overgrown with pubescence), the last of which, on segment five, is subobsolete; hind margins of segments yellowish, with a fringe of yellowish hairs; better preserved specimens show, on segments two and three, traces of lateral oblique yellowish spots. Venter rufous, last two or three segments black. Front legs black, base of tibiæ reddish; on the hind legs the end of the femora, the tibiæ and tarsi are rufous; tibiæ with a fringe of black hairs. Wings with a faint brownish gray tinge, more marked in the costal cell and across the central crossveins; first posterior cell broadly open. Length, 17–20 mm.

Hab. Northern United States and British Possessions. I have about three dozen specimens from Fort Good Hope, Lake Athabasca, Portage and Slave Lake, Lake Winnipeg, Lake Superior (Michipicoten); Bethel, Me.; White Mts., N. H.

The antennæ are sometimes black, with a trace of red at the base of the third joint only. The identification cannot be doubtful, as this is the largest among the allied species.

49. Tabanus socius n. sp.

Female. Is very like *T. affinis*; it will be sufficient to indicate the differences. Smaller in size, being only 15–16 mm. long: the coloring of the dark portions is of a lighter gray, somewhat slate color; the second joint of the palpi is shorter and much stouter at the base, the color of the palpi is paler; antennæ of a lighter red, last joint but very little infuscated towards the end; the yellowish brown at the base of the front tibiæ is more extended here, in many specimens the tibiæ are black at the tip only; the front is distinctly coarctate anteriorly, but narrower than in *T. affinis*; the linear prolongation of the callus in most specimens forms a slightly elevated ridge, sometimes nearly reaching the ocellar tubercle. Length, 15–16 mm. I have about a dozen of specimens from the northwestern parts of the Hudson's Bay Territory (Fort Simpson, Kennicott), agreeing in these characters; also two specimens from Illinois. All these specimens have the antealar tubercle reddish.

This species is most remarkably like the common European *T. tropicus*; however, a specimen of the latter in the Museum of Comparative Zoology, labelled by Dr. Loew, has a somewhat broader front, the antealar tubercles black, the antennæ somewhat more brownish at the tip. I sent a specimen of *T. socius* to Dr. Loew, who declared it to be different from his *T. tropicus*.

There seems to be a good deal of uncertainty connected with the European species of this group. Dr. Schiner, Fauna Austr., Diptera, I, p. 30–31, makes *tropicus* (non Linné) Loew = *solstitialis* (Meig.) Schiner; *tropicus* (Linné) Schiner = *luridus* (non Fallèn) Loew; and *luridus* Fallèn (non Loew) = *tropicus* Panzer. Loew observes (Verh. Zool. Bot. Ges., 1858, p. 586), in a note to the description of *T. tropicus*, that "the difficulties concerning this species are increased by the fact that there are evidently several other species yet coming in conflict here, which cannot be distinguished with certainty in single specimens." Similar difficulties probably exist among the North American species.

T. vicinus Macq., Dipt. Exot., I, 1, p. 143, 44 (Carolina) apparently belongs in this relationship.

50. Tabanus septentrionalis.

Tabanus septentrionalis Loew, Verh. Zool. Bot., 1858, p. 593.

I translate Dr. Loew's description:

"*Female.* Ex-cinereo nigricans, abdomine trifariam cinereo maculato, maculis lateralibus obliquis, margini postico vix contiguis, tibiis obscure testaceis, oculis hirtis, trifasciatis, palpis nigropilosis, antennis nigris, frontis callo infero et linea longitudinali media atris. Long. corp. 6 lin.; long. al. $5\frac{1}{6}$ lin.

"(Cinereous blackish, abdomen with three rows of cinereous spots, the lateral ones oblique, hardly touching the hind margin, tibiæ dark testaceous, eyes hairy, with three stripes, palpi with black hairs, antennæ black; frontal callosity and a longitudinal line in the middle, black; length 13 mm.)

"The great uniformity which prevails through the whole dipterous fauna in the arctic regions, and the resemblance between *T. septentrionalis* and the two preceding species,[1]

[1] *T. quatuornotatus* Meig. and *nigricornis* Zett.

may serve as an excuse for my mentioning this species among those of the European fauna. It is smaller than the other two, its coloring is a darker blackish gray, with an admixture of brown. Face and front yellowish cinereous; the former, as well as the cheeks, is beset with black and pale yellowish hairs. The palpi, of a dirty whitish, are beset with black hairs, not only on the second, but also at the end of the first joint; a character especially distinctive of this species. Antennæ black, only the third joint, at the extreme basis sometimes dark reddish, the first in the shape of a cap (Kappenfoermig), and beset, as well as the second, with short black hairs; the third joint is but little excised. Front of medium breadth, with a square, shining black callosity, above which is a shining black longitudinal line, not quite connected with the callosity. Eyes strongly pubescent, with three cross-bands, which have the same position as in *T. quatuornotatus*. With the soft, pale yellowish pile on the thoracic dorsum, the pleuræ and the coxæ, many black hairs are mixed; the pollinose pale longitudinal lines on the thorax are but little apparent, the intermediate one especially is almost obsolete. The lateral spots on the abdomen are more rounded than in *T. quatuornotatus*, but in a similar position; the hind margins of the segments have a delicate, rather whitish fringe of hairs; the broad longitudinal stripe in the middle of the blackish gray venter is usually more distinct than in the related species, as the coloring of the anterior segments beside it is often reddish; when this is not the case, the stripe is hardly more apparent than in the other species. Femora black, mostly with black hairs; the extreme tip of the femora and the tibiæ yellowish brown, the latter more or less blackish at the end. Wings with a more distinct dusky tinge than in *T. quatuornotatus* and *nigricornis*, the stigma dark brown, the first posterior cell a little more coarctate at the tip than in those species."

Hab. Labrador.

1. Among the numerous specimens belonging in the vicinity of the European *T. quatuornotatus*, I have a single one, likewise from Labrador (Caribou Island, Straits of Belle Isle, A. S. Packard), which answers the above description with regard to the black hairs on the cheeks and on the first joint of the palpi; only it is a little larger (between 14 and 15 mm.).

2. Two other specimens from Labrador agree in all respects with the former; they are a little smaller, and have no black hairs on the cheeks, or on the first joint of the palpi.

3. Two specimens from Yukon River, Alaska (R. Kennicott), agree in everything with the specimen from Labrador, first mentioned, except that they have no black hairs on the cheeks and on the first palpal joint.

4. Seven specimens from Lake Winnipeg (Scudder), and five from some other localities (Massachusetts; Michipicoten, Lake Superior, Quebec, Canada), have the sides of the abdomen reddish on the first three or four segments, and the venter more or less reddish. They are more slender than the specimens from Labrador and Yukon River, and the triangles in the middle of the abdominal segments in most of them seem larger and more distinctly marked; the base of the third antennal joint is bright red in most of these specimens.

5. Three specimens from Maine (Mount Desert and the sea shore, B. P. Mann), and one from Minnesota (Scudder) are smaller than the former lot (12.5 mm.), without any reddish on the sides of the abdomen, and have the gray spots on the abdomen, both intermediate and lateral, very distinct.

Some of these groups of specimens, especially the groups 3 and 4, may really belong to different species, although I confess myself unable to characterize them as such to my own satisfaction. They all have the same characteristic comparatively narrow and hardly excised third antennal joint; nor do I perceive any appreciable difference in the shape of the front or of the palpi. Some of them even have a few black hairs on the cheeks and on the first joint of the palpi, but not nearly so distinctly as the specimen from Labrador of the group No. 1.

51. Tabanus illotus n. sp.

Female. Eyes pubescent: front rather broad, slightly converging anteriorly, brownish, mixed with gray, beset with black hair; callosity black, nearly square, its linear prolongation above but weakly marked, usually appearing as an ill defined oblong dark spot. Face and cheeks of a rather pure grayish white, with white hairs; palpi stout, pale yellowish, with small black hairs. Antennæ: third joint moderately broad and moderately excised, with a well marked upper angle; its color is more or less dark reddish, its distal half black. Thorax blackish, with faint gray lines, antealar tubercles usually reddish, pleuræ gray, with long, white hairs. Abdomen blackish; on the second segment two obliquely placed whitish (in rubbed off specimens pale reddish) lateral spots, not touching the hind margin (the whitish pollen and pubescence covering them reach the margin); on the third segments two much smaller and rounded spots, of the same color; on the following segments two still smaller whitish, rather faint spots, visible only in well preserved specimens, and without any reddish under them; more of these spots are in contact with the hind margin of the segment; between these lateral spots triangular intermediate spots contiguous to the hind margin are more or less visible, especially on the second and third segments. The venter is covered with a delicate white pollen and with minute whitish hairs; its ground color is black, with more or less reddish in the middle, and a blackish stripe upon it. Coxæ and femora black, with a whitish pollen and long white hairs: front tibiæ reddish yellow, black towards the tip: middle tibiæ altogether reddish, the hind tibiæ reddish brown; all the tibiæ beset with whitish hairs, the fringe of the last pair consisting sometimes of white, sometimes of black hairs, or of both mixed: tarsi brown. Wings subhyaline; faint brownish clouds on the central crossveins, at the base of the second posterior cell and on the bifurcation of the third vein; stigma brown. Length, 12–14 mm.

Hab. Fort Resolution, Hudson's Bay Territory (R. Kennicott); Yukon River, Alaska (Kennicott); Red River of the North (Scudder). I have a dozen specimens before me.

This species is easily recognized among others by the rather conspicuous spots on the second and third abdominal segments, while the spots on the following segments are smaller and much less visible. In many specimens a reddish ground color shines through the spots on the segments two and three, while it never appears on the following segments. The faint clouds on the crossveins are also a good distinguishing character.

I have two specimens from Fort Resolution, one from Lake Winnipeg (Scudder), one from Quebec (Bélanger), two from Labrador (Caribou Island, Straits of Belle Isle, A. S. Packard), one from Anticosti (Verrill), and one from Minnesota, all of which have the face and cheeks, as well as the hair upon them, somewhat yellowish, instead of pure grayish white or white; the small black hairs on the palpi are denser, especially towards the tip, making the palpi

appear darker; in one of the specimens (Quebec) there are black hairs, even on the first joint; the wings have a more distinct brownish tinge, especially the costal and the two basal cells; the underside of the body, including chest and pleuræ, is much darker, beset with blackish and yellowish, but no white hairs; on the femora also the pollen is more yellowish gray, less conspicuous, and the hairs on the front femora are black, on the hind ones yellowish; the gray spots on the third and the following segments seem to be larger. All these specimens have the subcallus denuded, black or brown, shining. In all other respects, and in general appearance, these specimens look exactly like the typical *T. illotus*. It may be that this is a different species.

52. Tabanus microcephalus n. sp.

Female. Head small, in comparison to the bulk of the body; eyes pubescent; front of moderate breadth, hardly narrowed anteriorly, gray, mixed with brownish; callosity black or brown, prolonged above in a rather stout black line; vertex blackish; the black hairs on the front are short and inconspicuous. Palpi yellowish, stout at the base, tapering in a rather elongated point, clothed with short black hairs; face grayish white, with white hairs; antennæ more or less dark reddish; first joint often nearly black, with grayish pollen above, the third black towards the tip; the shape of the third joint is peculiar: it is narrow, the body of the joint is rather small, hardly excised above, thus having a blunt and but little projecting upper angle; the annulate portion is stout, the joints composing it very distinct. Thorax grayish black, with rather distinct gray lines; pleuræ gray. Abdomen rather large, in comparison to the size of the thorax, grayish black, with three distinct rows of gray spots; the spots of the intermediate series are triangular, the largest and most distinct on the second and third segments, where their apex often has a linear prolongation reaching the anterior margin of the segment; the lateral spots are oblique triangles, resting on the hind margins of the segments, and having their outer ends prolonged towards the lateral margin. Venter grayish, the reddish ground color being often visible under the gray pollen. Wings subhyaline; stigma dark brown; first posterior cell broadly open. Legs reddish brown, clothed with blackish and whitish hairs; tarsi darker; femora with gray pollen (sometimes they are dark brown). Length, 14–16 mm.

Male. I have three males before me, which, owing to the structure of their antennæ, I refer to this species. They do not materially differ from the female, except that the head is comparatively larger; the hairs on cheeks and palpi are black; the abdominal markings less distinct. The largest of the three specimens (nearly 16 mm.) has the sides of the abdomen red on segments one to four; owing to this ground color the lateral gray spots are but little apparent. In the second specimen, which is a little smaller, there is less red on the sides; in the third (about 12 mm.) the red is hardly perceptible, and the lateral gray spots are more distinct. These specimens were taken in the White Mountains, with a number of females, by Mr. Morrison.

Hab. White Mts., N. H. (Scudder and Morrison); Trenton Falls, N. Y. (in July, 1874, by myself); Massachusetts (Sanborn). I have twelve females and three males before me.

The eyes of this species have four green stripes, the two inner ones especially brilliant bluish green; intermediate spaces purple. The shape of the antennæ, and the peculiar

outline of the whole body (in the female), owing to the comparatively small head and large abdomen, will render the recognition of this species easy.

53. Tabanus astutus n. sp.

Female. Palpi long and narrow, not incrassated at the base, dark yellowsh with black hairs; face and cheeks grayish, with a slight yellowish tinge and gray hair; front rather broad, gray; callosity large, black, almost square; above it a somewhat lanceolate black spot, almost or entirely disconnected from the callosity. Third antennal joint moderately broad, and but little excised, still with a distinctly projecting upper angle; the color is dark reddish, black towards the tip; the segments of the annulate portion very distinct. Thorax grayish black, well preserved specimens with very distinct whitish gray, partly yellowish, lines; pleuræ gray. Abdomen grayish black, with three rows of whitish triangles resting on the hind margins of the segments; the lateral ones are oblique, obtuse angular, with the outer angle prolonged towards the lateral margin. Venter grayish, with whitish incisures, an indistinct dark longitudinal stripe in the middle. Legs brown; the four hind femora on the proximal half, the tarsi and the ends of the front tibiæ dark brown, nearly black; sometimes the legs are altogether black, except the proximal half of the tibiæ, which is brownish; in such specimens the gray pollen on the femora, and grayish yellow hairs on the femora and tibiæ, are more apparent. Wings nearly hyaline; stigma brown; first posterior cell broadly open. Length, 10–13 mm.

Hab. White Mts., N. H. (near North Conway, Aug. 16, 1874, two specimens taken by me); Manlius, N. Y. (J. H. Comstock); Southington, Conn. (in July, W. H. Patton). I have six females before me.

The coloring and the markings of this species resemble *T. microcephalus* very much; but the *T. astutus* is smaller, and the general outline is different, as it has neither the small head nor the large abdomen of the former. The most striking distinctive character, however, consists in the palpi, which here are long and narrow, and not so much incrassated at the base as in *microcephalus*. The front is much broader here, and the antennæ have a more distinctly projecting upper angle. The eyes "are not unlike those of *microcephalus*, only the middle stripes more green than blue; the upper one very little marked"; (note taken by me from the living specimens).

The old and faded specimens, which I consider to be females of *T. vivax* (see No. 20), are not unlike this species; they differ, however, in having the eyes glabrous, and the lateral abdominal spots more distinctly angular rather than triangular, that is, in having the longest oblique side more distinctly excised in the middle; the palpi are broader and more knee-shaped at the base of the second joint; the general outline of the body is different, the thorax being comparatively longer and the abdomen narrower; the third antennal joint is somewhat broader; the anterior of the three short veins, connecting the discal cell with the margin, is straighter, not so markedly arcuate as it is in *T. astutus* and *T. microcephalus*.

The males, of course, will be easier to distinguish, that of *T. vivax* having a large head, with the large and small facets very distinctly differentiated; while the unknown male of *T. astutus* must belong to the group with the small heads and but little differentiated facets.

54. Tabanus rhombicus n. sp.

Female. Front comparatively broad, gray, slightly coarctate anteriorly; callosity black, with a black, shining subcallus; face whitish gray, with white hairs; palpi yellowish, stout at base, clothed with short, black hairs; antennæ more or less dark reddish, the third joint black, more or less red at base, its upper angle very shallow. Thorax grayish black with gray lines; pleuræ gray. Abdomen grayish black, with gray spots, as follows: on the second and third segments an equilateral triangle in the middle, and an oblique one on each side; the following segments show a grayish hind margin, with a fringe of grayish hair expanded into a very faint triangle in the middle, and but slightly expanded on each side, where the lateral triangles should lie; (all these markings seem to rub off very easily; especially the intermediate row of triangles, formed of hairs only, with hardly any gray pollen under them); the sides of the second segment sometimes faintly reddish. Venter blackish, with a dense gray pollen and fringes of whitish hairs; sometimes the first and second segments are faintly reddish on the sides. Femora black, with gray pollen; tibiæ and tarsi reddish brown; front tibiæ on their distal half and front tarsi dark brown (in some specimens the tibiæ and tarsi are much darker than in others). Wings subhyaline; stigma brown; a very faint, small cloud on the bifurcation of the third vein and at the base of the second posterior cell; first posterior cell broadly open. Length, 13–15 mm.

Hab. Colorado Mountains (Lieut. W. L. Carpenter, J. Ridings). I have six specimens, only one of which can be called tolerably well preserved. Four specimens from British Columbia (Crotch) seem to belong to the same species. Two specimens from the British Possessions (Saskatchewan or Lake Winnipeg, S. H. Scudder) may perhaps also belong here; they are smaller, somewhat narrower, and the abdomen more reddish on the sides.

T. rhombicus is very like *T. microcephalus* in its general appearance, but its head is comparatively larger, the front broader, the subcallus (in all my specimens at least) is denuded, the bifurcation of the third vein shows a little cloud, which, although faint, is sufficiently distinct, the femora are darker, etc. In most specimens the ocellar tubercle is not denuded of pollen, although the eminence is plainly visible. The markings of the abdomen are very like those of *T. microcephalus*, only the triangles of the intermediate row are larger.

List of the previously described Species which remain unknown, unrecognized or doubtful; all from North America, north of Mexico.

Linné.

T. calens (Syst. Nat., p. 1000, 6) is *not gigantens* DeGeer (= *lineatus* Fab.), although quoted by DeGeer; about the confusion existing with regard to this species, see Wiedemann, Auss. Zw. I, p. 135. The name is better left in abeyance for the present.

T. exastuans (Syst. Nat., II, p. 1000, 8); see No. 10, *T. melanoccrus* Wied.

Fabricius.

T. marginalis (Syst. Antl., 99, 31). Very doubtful species; doubtful also whether Wiedemann described the same species (compare Auss. Zw., I, p. 166); my No. 20, *T. vivax*, seems to be the nearest to it.

Palisot-Beauvois.

T. ferrugineus (Tab. III, f. 2, p. 221).

T. nebulosus (Tab. III, f. 4, 5, p. 222).

T. pallidus (Tab. III, f. 3, p. 100).

T. palpinus (Tab. III, f. 1, p. 221).

I cannot make out these species.

WIEDEMANN.

T. annulatus Say. (Auss. Zw., I. p. 185). Certainly not among the species of which I have specimens.

T. gracilis (Auss. Zw., I, p. 156, 71, Georgia) unknown; see *T. tener* O. S. No. 11.

T. nigripes (Ibid., p. 142, 50); see No. 13, *T. coffeatus* Macq.

MACQUART.

T. baltimorensis (Dipt. Exot., 5e Suppl., p. 34; Baltimore). Perhaps *T. costalis* Wied.?

T. bicolor (Ibid., 2e Suppl., p. 21; South Carolina). Perhaps *T. giganteus* DeGeer, female? Compare this species (No. 37).

T. cæsiofasciatus (Ibid., 5e Suppl., p. 32; Baltimore). Perhaps *T. giganteus* DeGeer, male? See this species (No. 37).

T. carolinensis (Ibid., I, 1, p. 145; Carolina); belongs in the group of *T. socius*, or perhaps of *T. microcephalus*, *astutus*, etc.?

T. cingulatus (Ibid., I, 1, p. 144, 46; Philadelphia). I do not recognize this species.

T. dorsonotatus (Ibid., 2e Suppl., p. 22; Carolina; a male). May be the male of *T. rufus* Pal. No. 34, which I have not seen?

T. fusconervosus (Ibid., I, 1, p. 147, 42; no locality; Walker, List, etc., I, p. 149, has it from Florida). May be *T. turbidus* Wied. No. 1.

T. hirtioculatus (Ibid., 5e Suppl., p. 33, 128; Baltimore; a male). *Eyes pubescent.* I do not know this species. The words "antennes . . . . à dent un peu allongée," may betray the male of my *T. cerastes* No. 42.

T. nanus (Ibid., 1er Suppl., p. 42, 88; Texas); see my *T. psammophilus* No. 18; the name is preoccupied by Wiedemann.

T. Novæ Scotiæ (2e Suppl., p. 24, 110). Unrecognizable.

T. punctipennis (2e Suppl., p. 23, 108; Philadelphia). Agrees exactly with *T. lasiophthalmus* No. 47, except that the pubescence of the eyes is not mentioned. In any case the name must be given up, as there is an earlier *T. punctipennis* by Macquart himself; Dipt. Exot., I, 2, p. 185.

T. vicinus (Ibid., I, 1, p. 143, 44; Carolina); of the group of my *T. socius* No. 49.

T. unicolor (Ibid., 2e Suppl., p. 22, 107; Carolina). I no not know this species. There is a much earlier *T. unicolor* Wied.

RONDANI.

T. cheliopterus. I transcribe the rather inaccessible description. (Female.) *Oculi* nudi. Antennæ superne in dentem non extensæ, fulvæ. *Palpi* fulvescentes. *Frons* rufa. *Facies* sordide albicans. *Thoraæ* dorso fulvo-rubescente, pleuris paulo griseocentibus. *Scutellum* fulvo-rubescens, margine paulo griseo. *Abdomen* fulvo-rufescens, segmentis penultimo et præcedente in medio paulo fuscis; omnibus lineola marginali postica, parum manifesta, sublutescente. *Squamæ* et *halteres* fulvescentes. *Pedes* fulvo-rufi, tarsis vix obscurioribus, et geniculis angustissime lutescentibus. *Alæ* paulo infuscatæ, circa venas aliquantulum fusco lutescentes, ad venarum conjunctiones fusco-nigricantis (*sic*) maculatæ. Stigmata et costa anguste fusco-lutea. Longit., millim. 18. Carolina. (Nuovi Annali di Sc. Nat. di Bologna, Sept.–Oct., 1850.)

I do not know this species.

WALKER.

T. comes (List, etc., I, p. 172. *T. inscitus*; changed into *T. comes*, Ibid., V, p. 173; Hudson's Bay Terr.; Nova Scotia). The author describes a specimen without head. I find in my notes that when, in 1859, I visited the British Museum, *T. comes* was represented in it by five specimens, belonging to three different species, all of them of the difficult groups of *T. marginalis* Wied., or *T. illotus* O. S.

T. confusus (List, etc., I, p. 147; Georgia).

T. imitans (List, etc., I, p. 146; Georgia).

Both of the group of *T. abdominalis*; perhaps this very species.

T. conterminus (Dipt. Saunders., p. 24; United States). The description of the abdomen suggests *T. costalis*; but the thorax is said to be gray, with hoary hairs.

T. divicatus (List, etc., I, p. 151; North America). Walker says he describes a male; in the British Museum I saw a single female specimen, which, at that time, I did not recognize. The description suggests nothing to me now, and is rather unmeaning. There is some confusion in the Latin diagnosis, where in the third line, *nigris* must, I suppose, be read instead of *fulvis*.

T. duplex (List, etc., I, p. 173, *T. imitans*; name changed, ibid., V, p. 173; Hudson's Bay Territory). I cannot identify it.

T. frontalis (List, etc., I, p. 172; Nova Scotia). Said to be allied to No. 48, *T. affinis* Kirby, but will be difficult to identify from the description.

T. fulvofrater (List, etc., I, p. 181; Illinois). In the British Museum a single very bad and indistinct specimen. The description is absolutely unmeaning.

T. incisus (Dipt. Saund., p. 26; Cape Breton). Unknown; the abdomen must be somewhat like that of *T. lineola*.

T. intermedius (List, etc., I, p. 173; Hudson's Bay Territory; male and female). Unknown.

T. leucomelas (List, etc., I, p. 175; Georgia). Description very unmeaning; in coloring it seems to be like my *T. socius*, or like *T. vicinus* Macq.

T. mutatus (Dipt. Saund., I, p. 23; United States). The description suggests *T. costalis* Wied., or some species closely resembling it, but larger.

T. patulus (List, etc., I, p. 175; Georgia). I do not know this species.

T. proximus (List, etc., I, p. 147; Florida) is ten lines long; very probably described from an unrecognizable specimen of some well known species.

T. recedens (List, etc., I, p. 147; Florida). Must be like my No. 5, *T. catenatus*, perhaps the same.

T. rufofrater (Dipt. Saunders, I, p. 26; Georgia). Very incomplete description, perhaps my No. 13, *T. tener*.

T. scitus (List, etc., I, p. 181) comes nearest to my No. 42, *T. cerastes*, on account of the structure of the antennæ; in other respects the description is unmeaning.

T. triliguttus (List, etc., V, p. 183; Arctic America); apparently a somewhat smaller specimen of No. 48, *T. affinis* Kirby. The description of antennæ and palpi, and of the brownish coloring, excludes the synonymy of No. 49, *T. socius*.

Additions to Part I of the Prodrome of the Tabanidæ of the United States.

Chrysops pudicus (page 381). Three female specimens from Ft. Capron, Florida, April 11, 12 (collected by Messrs. Hubbard and Schwartz), do not seem to differ from my other specimens; only the distal margin of the crossband of the wing is straighter, and not slightly sinuate in the third posterior cell, as I find it in my typical specimens.

Two females from Sag Harbor, Long Island (caught by myself in July, 1875), *have an altogether black frontal callosity*; the coloring of the body and wings is darker and more, intense, and the outlines of the abdominal spots and the design of the wings are better defined. In other respects the agreement with the typical specimens is perfect.

Chrysops morosus (page 389). Three females and a male from Florida (Cedar Keys, June 4; Ft. Capron, April 9; Indian River, April) do not show any trace of yellow abdominal stripes, and agree in this respect with the specimens mentioned in Part I. p. 390. I think now that such specimens belong to *C. morosus*, which would in this case occur as often with as without yellow stripes on the abdomen. I also feel more inclined now than before, to identify this species with *C. lugens* Wied.

Chrysops frigidus, female (page 384). Varieties occur in which the red of the abdomen prevails at the expense of the black. An extreme case of this kind was communicated to me by Mr. Dimmock, in which even the facial callosities were reddish. In this specimen the second segment was altogether reddish, except a small subtriangular spot in the middle; the two following segments were blackish along their anterior margin only; the last three segments, although black, were laterally and posteriorly margined with yellow. For

such exceptional specimens the analytical table of course cannot serve. Mr. Dimmock had seen a male, and I now entertain no doubt that the two sexes, as described by me, belong together.

Diabasis (page 396). In preparing the first part of this paper I had neglected to search the title to priority of the genus *Diabasis*. I find now that the name is preoccupied by Hoffmannsegg in Wiedemann's Zoolog. Magazin, I, 1, p. 44, 1817, for a group of *Rutelæ* (Coleoptera). The genus is also accepted in Harold and Gemminger's Catalogue. For the Tabanid I propose therefore the name *Diachlorus* which means striped with green in allusion to the color of the eyes.

List of the described Tabanidæ from Mexico, Central America and the West Indies.

PANGONIA.

aurulans Wiedemann, Auss. Zw., II, p. 620, 12. Mexico.
atrifera Walker, Trans. Ent. Soc., N. S., V, p. 272. Mexico.
flavohirta Bellardi, Saggio, etc., I, p. 49. Mexico.
fulvithorax Wiedemann, Auss. Zw., I, p. 89; Bigot, in R. de la Sagra, etc., p. 797. Brazil (Wied.); Cuba (Bigot).
incerta Bellardi, Saggio, etc., I, p. 52. Mexico.
nigronotata Macquart, Dipt. Exot., 4e Suppl., p. 27, 56; Tab. II, f. 5; Bellardi, Saggio, etc., I, p. 51. Mexico.
planiventris Macquart, Dipt. Exot., 4e Suppl., p. 26, 55. Mexico.
rhinophora Bellardi, Saggio, etc., I, p. 46; Tab. II, f. 1. Mexico.
rostrifera Bellardi, Saggio, etc., I, p. 47. Mexico.
Sallei Bellardi, Saggio, etc., I, p. 50. Mexico.
Saussurei Bellardi, Saggio, etc., I, p. 49, Tab. II, f. 4. Mexico.
semiflava Wiedemann, Auss. Zw., II, p. 622, 16; Bellardi, Saggio, etc., I, p. 51, Tab. II, f. 2. Mexico.
tenuirostris Walker, Trans. Ent. Soc., N. S., V, p. 272. Mexico.
Wiedemanni Bellardi, Saggio, etc., I, p. 48, Tab. II, f. 3. Mexico. *T. basilaris* Wiedemann, Auss. Zw., II, p. 621.

LEPIDOSELÆGA.

lepidota Wiedemann, Auss. Zw., I, p. 193 (*Tabanus*); Perty, Delectus, etc., p. 183, Tab. XXXVI, f. 9 (*Hadrus*); Macquart, Dipt. Exot., I, 1, p. 154, Tab. XVIII, f. 3; Bellardi, Saggio, etc., I, p. 75 (*Hadrus*); according to Loew, Centur., VIII, 8, only the female described by Bellardi, belongs here. Brazil, Guyana (Macquart, Perty); Mexico (Bellardi). *Hæmatopota crassipes* Fabricius, Syst. Antl., p. 108, 4. (Synonymy after Loew, l. c.)
recta Loew, Centur., VIII, 8. New Granada; Mexico. *Hadrus lepidotus* Bellardi, Saggio, etc., I, p. 75; *male*. (Synonymy after Loew, l. c.)

DICHELACERA.

fasciata Walker, Dipt. Saund., I, p. 68. North America.
abiens Walker, List, etc., I, p. 191. West Indies.
scapularis Macquart, Dipt. Exot., 2e Suppl., p. 15, 9. Mexico.

CHRYSOPS.

gigantulus Loew, Centur. X, 12. California.
affinis Bellardi, Saggio, etc., I, p. 70, Tab. II, f. 14. Mexico.
apicalis Bellardi, l. c., p. 73. Mexico.

crucians Wiedemann, Auss. Zw., I, p. 211. Brazil (Wied.); Cuba (Jaennicke, Neue Exot. Dipt., p. 4).
costatus Fabricius, Ent. Syst., IV, p. 373, 45 (*Tabanus*); Syst. Antl., p. 112, 8; Palisot, Ins., Dipt., p. 22, Tab. III, f. 7; Wiedemann, Dipt. Exot., I, p. 104, 4; Auss. Zw., I, p. 198, 5; Macquart, Dipt. Exot., I, 1, p. 160, 8; Bigot, R. de la Sagra, etc., p. 798; Guérin, Iconogr., Texte, III, p. 542, Tab. XCVII, f. 3 (called *C. molestus* on the plate). S. America (Fabr.); Cuba (Macq.); Jamaica (Walk.). *Tabanus variegatus* DeGeer, Tab. XXX, f. 7. (The synonomy is very probable.)
frontalis Macquart, Dipt. Exot., I, 1, p. 160, 7. West Indies.
geminatus Wiedemann, Auss. Zw. I, p. 205, 16; Macquart, Dipt. Exot., 4e Suppl., p. 39. Patria ignota, (Wied.); Mexico (Macq.).
inornatus Walker, List, etc., I, p. 198. West Indies, Brazil.
lateralis Wiedemann, Auss. Zw., I, p. 209, 21; Walker, List, etc., I, p. 200; V, p. 288. Patria ignota (Wied.); Honduras (Walk.).
latifasciatus Bellardi, Saggio, etc., I, p. 71, Tab. II, f. 15. Mexico.
megaceras Bellardi, l. c., p. 74; Tab. II, f. 18. Mexico.
pallidus Bellardi, l. c., p. 73, Tab. II, f. 16. Mexico.
scalaratus Bellardi, l. c., p. 72, Tab. II, f. 19. Mexico.
subcæcutiens Bellardi, l. c., p. 69, Tab. II, f. 13. Mexico.
virgulatus Bellardi, l. c., p. 71, Tab. II, f. 17. Mexico.

TABANUS.

albiscutellatus Macquart, Dipt. Exot., 4e Suppl., p. 34, Tab. II, f. 9.
albonotatus Bellardi, Saggio, etc., I, p. 56, Tab. II, f. 5.[1] Mexico; Tampico.
alteripennis Walker, Trans. Ent. Soc. N. Ser., V. p. 274. Mexico.
aurantiacus Bellardi, Saggio, etc., I, p. 67; Tab. II, f. 9. Mexico.
Bigoti Bellardi, Saggio, etc., I, p. 59. Mexico.
apicalis Macquart, Dipt. Exot., 2e Suppl., p. 20; Walker, List, etc., V, p. 188.
bipartitus Walker, List, etc., I, p. 158. Honduras.
caliginosus Bellardi, Saggio, etc., I, p. 68, Tab. 22, f. 10. Mexico.
carneus Bellardi, Saggio, etc., I, p. 62. Mexico.
circumfusus Wiedemann, Auss. Zw., II, p. 624, 21. Mexico.
commixtus Walker, Trans. Ent. Soc., N. Ser., V, p. 273. Mexico.
completus Walker, List, etc., I, p. 185. St. Thomas.
Craverii Bellardi, Saggio, etc., I, p. 60. Mexico.
De filippii Bellardi, Saggio, etc., I, p. 57. Mexico.
dorsifer Walker, Trans. Ent. Soc., W. Ser., V, p. 273. Mexico.
ferrifer Walker, Dipt. Saund., I, p. 30. West Indies.
flavo-cinctus Bellardi, Saggio, etc., I, p. 61. Mexico.
lucidulus Walker, List, etc., I, p. 188. Jamaica.
luteo-flavus Bellardi, Saggio, etc., I, p. 60. Mexico.
longiappendiculatus Macquart, Dipt. Exot., 5e Suppl., p. 32, 125. Honduras.
nigro-punctatus Bellardi, Saggio, etc., I, p. 67, Tab. II, f. 8. Mexico.
obliquus Walker, Dipt. Saund., I, p. 28. West Indies.
propinquus Bellardi, Saggio, etc., I, p. 65. Mexico.
purus Walker, Trans. Ent. Soc., N. Ser., V, p. 274. Mexico.
quinquevittatus Wiedemann, Dipt. Exot., I, 84, 39; Auss. Zw., I, p. 173, 93; Bellardi, Saggio, etc., I, p. 65. Mexico.
oculus Walker, List, etc., I, p. 197. Honduras, Columbia.

[1] This species has the first posterior cell closed, and petiolate at the distal end. Mr. Rondani (Diptera exotica revisa et annotata, etc., Modena, 1863, p. 81, fig. 12, 13) proposes for this species the establishment of a new genus *Bellardia*, which would also include Macquart's species *T. maculipennis, clausus, limbatinervis*. The genus, however, cannot be maintained.

parallelus Walker, List, etc., I, p. 187. West Indies.
parvidentatus Macquart, Dipt. Exot., I, 1, p. 140; Walker, List, etc., V, 189. West Indies.
rubescens Bellardi, Saggio, etc., App., p. 15. Mexico.
rufiventris Macquart, Dipt. Exot., I, 1, p. 141, 39; Walker, List, etc., I, p. 180; Bigot, R. de la Sagra. p. 798. Cuba, Jamaica.
Sallei Bellardi, Saggio, etc., I, p. 61, Tab. II, f. 7. Mexico.
stigma Fabricius, Syst., Antl., p. 104, 50; Wiedemann, Dipt. Exot., I, 92, 53; Auss. Zw., I, p. 180, 104. South America and St. Thomas.
subsimilis Bellardi, Saggio, etc., I, p. 66. Mexico.
subtilis Bellardi, Saggio, etc., I, p. 55. Mexico.
subruber Bellardi, Saggio, etc., I, p. 55. Mexico. *ruber* Macquart, Dipt., Exot, 2e Suppl., p. 42; Walker, List, etc., V, p. 188.
Sumichrasti Bellardi, Saggio, etc., I, p. 56. Mexico.
tinctus Walker, Dipt. Saund., I, p. 29. West Indies.
trilineatus Latreille, Humb. et Bompl. Rec. d'Obs. de Zool., fasc. X, p. 116, 117, Tab. XI, f. 6; Wiedemann, Dipt. Exot., I, p. 84; Auss. Zw., I, p. 168; Walker, List, etc., V, p. 217; Bellardi, Saggio, etc., I, p. 63. Mexico.
Truquii Bellardi, Saggio, etc., I, p. 64, Tab. II, f. 6. Mexico.

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variegatus Fab., II, 437.
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XVIII. Revision of the North American Poriferæ; with Remarks upon Foreign Species. Part II.

By Alpheus Hyatt.

Read April 5, 1876.[1]

Since these Memoirs were begun, my views with regard to the affinities of the Sponges have changed completely, so that instead of regarding them as a class of Infusoria, I now look upon them as a distinct sub-kingdom or branch of animals, equivalent structurally to the Vertebrata, or any of the larger divisions which are characterized by the most important structural differences. The plan of these Memoirs does not permit me to discuss this question at present, nor is it requisite, since I have already published two papers bearing on this point, one prepared some months since for Johnston's American Encyclopedia, which will shortly appear, and one in the Proceedings of the Boston Society of Natural History for November, 1876.

In addition to the acknowledgments for assistance rendered by various institutions and individuals in the First Part of this Memoir, I have now most gratefully to add the following names. Prof. Baird, as Director of the National Museum, placed a fine collection of commercial "sorts" in my hands for identification. Dr. W. G. Farlow presented to the Boston Society of Natural History a fine collection, made on the south coast of Australia. The Academy of Natural Sciences of Philadelphia, loaned me their valuable collection of Keratose sponges. Mr. Gurdon Saltonstall made numerous inquiries with regard to the influence of physical agencies upon the West Indian Spongiæ at Nassau, and contributed thereby information having a very important bearing upon the questions discussed in the following pages. Mr. Geo. Brown Goode of Wesleyan College, Middletown, who is now collecting at Bermuda, has furnished me with information of general importance, and I am also indebted to him for a complete suite of the Spongiæ of that locality selected so as to show the varieties. Dr. E. Ehlers of Göttingen, in the most generous manner, forwarded his preparations of the skeletons of the original specimens in Esper's collection, which have been invaluable for comparison. The Messrs. Isaacs of New York gave me every facility for the examination of their large warehouse-stock of Mediterranean and American sponges, and presented several valuable specimens to the Museum of the Society. Messrs. Weeks and Potter of Boston, have also been very kind in the same way, and have presented to the Society's Collection, among others, the handsome specimen figured on Pl. 16, fig. 21.

[1] Considerable additions have been made to this paper since it was read.

Sub-order SPONGINÆ.

Family Spongiadæ.

The skeleton of this group differs from that of the Aplysinæ, as pointed out by Bowerbank and Schmidt, in the absence of the large tube occupying the axis of the fibres. The fibre is generally spoken of as solid, but in reality has a minute channel in the interior, which sometimes seems to be absent in dried specimens. This is probably due to the contraction of the walls of the fibre, for normally there exists in all fibres and spicules, at some stage of their growth, a hollow axis. The aspect of the keratose material is also similar to what it is in the Aplysinæ, consisting of concentric layers, and the intimate structure of these layers or concentric coats does not differ essentially. They are made up of fine fibrillæ, which may be observed at the broken ends of fibres in most species, whereas in the Aplysinæ, these concentric coats appear to be composed of more homogeneous keratode, and the fibrillæ are distinguishable only in the coarser skeletons. The fibrillæ are continuous, and not at all similar in aspect to the curious bulbous headed threads observed in some species of the Hircinidæ.

There seems to be a direct connection between the dermal membrane and the vertical or radiatory fibres, and in some cases also between this part and the secondary or connecting fibres. This is unquestionably also the case in the genus Tuba, and other true Chalina forms.

In Spongia proper, the dermal membrane is loaded with foreign matter in some localities, and these find their way into the fibres very rapidly. The commencement of a fibre is trumpet-shaped, the keratose matter gradually shading off into the soft membranous dermal coat of the exterior of the sponge.[1] As the whole mass increases in size, this introversion of the dermal membrane carries into the centre of the fibre a string of broken siliceous spicules and grains of sand. The secondary or connecting fibres are not usually, except in *Hircinia campana* and *Dysidea fragilis*, loaded with any foreign material. This, and the frequent presence of aborted twigs, seems to indicate that they are formed by a process of budding from the primary fibres.

The same mode of formation is evident also in Aplysina and Tuba, but the dermal membrane appears to be harder and clearer of foreign matter. The keratose skeleton is not therefore, as is generally claimed, wholly the product of the mesoderm or sarcodous body of the mass, but partly an ectodermal product, and bearing in most cases the marks of its derivation, not only in the presence of foreign material, but in the continuously tubular structure of even the most solid looking fibres. The concentric coats of keratode are divisible into two kinds, those which are produced primarily by the growth of the extremity, which forms at one time several concentric coats, and those which are produced or deposited around these subsequently, and are evidently secreted by the mesoderm.

The range of form is quite as great as it is in the Aplysinæ. The mass of the forms in Spongia are solid and rounded, varying to the cup-shaped or fistular; none even of the fis-

[1] This is also shown by Barrois to be the case in the *Desmacidon fruticosa*. In the young of this species the spicules are shown in the figure and described by the author as gathered into bundles and enveloped by keratode, which is formed by a trumpet-shaped introversion of the ectoderm projecting into the mesoderm. Ann. des Sc. Nat., June, 1876.

tular forms can be said to be tubular, since the walls are always of such excessive thickness. Ceratella is the extreme aberrant form which represents the arborescent Janthellæ among the Aplysinæ. These two representative forms respectively represent two distinct groups of corals, the Janthella, as previously described, being closely similar in the aspect and structure of the skeleton to the genus Antipathes, while the Ceratellæ approximate in aspect more closely to the Gorgoniacæ, though the absence of the large internal fibres confines this analogy to the external aspect of the flattened branches and the appearance of the scattered oscules, which look like the dried polyparies of the Gorgonia-stock.

It is usual to regard the commercial Sponges as having no specifically distinct forms, and such is the case when they are compared with the more constant forms of the higher animals, and even of most of the lower classes of the invertebrates. But the extensive collections which have passed under my hands enable me to give a formula which expresses the possible range of variation in every species. The basis of the form is the same as that pointed out by Hæckel and others for the Calcareous sponges; namely, the simple fistular or vasiform, a single tube, with most of the excurrent oscules on the inner surface. There may be every possible combination of this form, the tubes being either in the same plane, and more or less isolated in a level mass of more solid tissue, or they may be closely approximated, forming a solid head, or they may arise into separate branches, each isolated branch being a distinct tube, or association of tubes. Another series of forms have solid branches, in which the oscules owe their existence in the mass to the conjunction of a number of the excurrent canals, and are scattered all over the external surface, as in Chalina.

This is not the way in which the fistular forms arise, although they have been generally supposed to be identical with the separate cloacal trunks of the solid masses. Thus the tubes may be divided into two classes, those which are continuations of the original cloacal trunks of the young, as in the true Spongiæ, and correspond to Hæckel's idea of a fistular form; and the ordinary fistular form, of which *Hircinia campana* affords admirable illustrations. When the latter is very perfect it is perhaps impossible to decide from adult specimens alone to which class it belongs, but an examination of the varieties will generally show how it arises, especially if the earlier stages of growth of the colony are investigated.

The ordinary fistular form is a tube which owes its existence to the growth of the general surface of a previously solid mass, and receives the discharge of the excurrent oscules, sometimes these oscules being almost wholly confined to its internal surface, while in other specimens they may be scattered equally over this and the external surface also. These are the true homotypes of the primitive cloacal orifice of the embryo, and thus, although the tube of the true fistular or, when widely open, the vase-shaped form, represents functionally a single excurrent trunk and orifice, it is to be distinguished from those which arise directly out of the mass of the sponge, in somewhat the same way that we can distinguish the general cloacal cavity of Pyrosoma from the anal outlets of the individual ascidians. It is really a pouch or cœcum, formed by the general surface of the sponge, and is not a continuation of any single internal channel or excurrent tube, as are the true excurrent oscula.[1] Thus we can divide the series of fistular forms very decidedly from the more solid branching forms, though the latter are often found combined with the former on the same colony. From

[1] Barrois' observations show that the true canals and the first grand cloacal trunk arise by a hollowing out of the endoderm in the young sponge after it becomes attached.

the young, which is always solid,[1] we may have either the fistular tube built up, or solid branching forms, or combinations of both, the fistular arising from the solid and branching, or, *vice versa*, the solid and branching springing from the sides of the fistular. Some of the Aplysinæ have a similar extensive range, but generally the variations are more limited; whereas among the Sponginæ the filling out of the entire series indicated above, is the rule, and any constancy the exception. Thus *Spongia graminea*, *Dysidea fragilis* and *Hircinia purpurea*, are exceptional, in so far as the species may be characterized to a certain extent by their forms, but these species are the least known of the group, and this can only be regarded, therefore, as a doubtful conclusion. It very often happens, also, that in a given locality a certain series of forms may be shown to be peculiar to the species; but these are likely to be indefinitely modified by the discovery of new localities, or new situations in the same locality.

The microscopical composition of the little tufts of primary fibres varies so that I can make no great use of them, as Schmidt claims to have done among the Mediterranean commercial sponges of the genus Spongia; but in the other genera the arrangement of the fibres in the interior is much more characteristic, and gives excellent specific characteristics. The size and fineness of the fibres and the mesh of the skeleton, are also of great value, but the most reliable characteristics are obtained from the surface of the prepared skeletons among the commercial sponges. Though still very important among the remaining genera of the sub-order, the surface is more characteristic of the genus than of the species. This is due to the fact that in Spongelia, Stelospongos and Dysidea, the character of the surface is more largely due to the nature and composition of primary or vertical fibres, which project more or less, whereas in Spongia proper the surface is very often less effected by the composition and form of the projecting tufts of primary fibres than by those which I have called secondary tufts, which are simply irregular projections of the mass of the skeleton.

This will be recognized by the study of the various forms of the American sub-species, "*tubulifera*," which has a peculiar even surface, similar to that of the European *Spongia officinalis* or cup-sponge, or by following through the various forms of *Spongia equina*, sub-species *gossypina*, with its extraordinarily tufted surface, or *Spongia agaricina*, sub-species *corlosia*, variety *dura*, with its hirsute exterior. In other genera no such wide differences exist between the external aspect of the varieties or species, the differences being principally in the greater or less fineness of the fibres and the mesh of the skeleton.

The great difficulty which is experienced in any attempt to distinguish species results from the extreme susceptibility of all keratose sponges to any change in external conditions. They appear to require for the production of the forms in abundance, tropical or sub-tropical seas, and attain by far their greatest development in the number of the forms and species in the West Indian Seas. The typical forms, the commercial sponges, are essentially confined to the waters of the Carribean Islands, Bahaman Archipelago, and the southern and western coasts of Florida in this hemisphere, and to the Mediterranean and Red Seas in the other. Australia affords a few forms, and I have heard, though I cannot substantiate the fact, of some species on the Atlantic coast of Brazil. Bermuda also has a few of the commercial kinds, which, according to Mr. Goode's report and the suite of specimens

[1] That is to say, a bulb with but one orifice or true cloacal oscule.

forwarded, are much coarser than the Key West, darker in color, and, in fact, just about intermediate between these and those of Australia. They are occasionally found in the stores, but as a rule, are used only by the fishermen themselves about their boats, the Bahama sponges being preferred for domestic purposes by the inhabitants. Of course no complete report can be written until Mr. Goode's collection, which is very large, and has been very carefully made, can be examined; but it appears that the finest forms grow only in the protected lagoons at depths varying from five to twenty feet on a sandy bottom. The temperature was not stated. They are cured in a very careless manner by exposure to the weather, a process which doubtless does not increase their value.

The true Spongiæ are all shallow water forms. In the Mediterranean, according to Eckhel,[1] they are not found below thirty fathoms, and in our own seas about the same probably, though not fished to greater depths than five fathoms. The fishery is principally carried on in the West Indies by the aid of a sort of hooked fork, two shepherd's crook-like hooks on a long pole. The fishermen cannot so successfully work at considerable depths with this instrument, as by diving, or with the diving apparatus or armor, and various forms of drags, etc., employed in the Mediterranean. The greater part of the fishery is accomplished between the depth of three and twenty feet, according to the report of Dr. Palmer, from which these remarks are principally derived. The finest qualities of American sponges are obtained in the Bahamas, the principal depot being at Nassau.

The process of preparation is not so careful as in Europe, probably owing to the greater coarseness and cheapness of the specimens. The actual fishing is done from boats, generally belonging to some schooner or larger craft. The boats are sent out from the vessel manned by two men. One sculls slowly along, while the other watches the bottom with a water glass. This is a tube about a foot square, closed by a pane of glass at the lower end, which prevents the reflection of light from the surface, and enables a keen observer to detect objects on the bottom at a considerable depth. When sponges are sighted a signal causes the sculler to stop the boat, the water glass is laid aside, and the sponges are dragged up by means of the hooks. When the fishing is at an end, or the vessel loaded, the cargo is taken to land and "killed," as it is called, by exposure for a few days to the air. After this, the now highly offensive mass is moved into the "crawls." These are pens made by driving stakes into the sand where the water is from six to ten feet deep. They are thrown into these cribs and left to be washed clean by the action of the surf. This takes about one week, at the end of which time the skeletons are examined, and if found to be entirely cleansed of animal matter, dried, sorted according to quality, and strung on cords a fathom in length. They are generally sold by the cargo. The bases are clipped off, and the sponge trimmed with shears and packed in pressed bales for transportation to New York or England, where they are largely used for the manufacture of pilot cloth, hats, etc.[2] They are not of sufficiently good quality to compete with Mediterranean sponges, and are therefore rarely employed for domestic purposes, except in Great Britain (?) and the countries of North and South America.

The fisheries near shore are abandoned in the winter on account of the turbid state of the water, which becomes "milky" with suspended coral sand during the more tempestuous

[1] Der Badeschwamm, by Von Eckhel. Trieste, 1873. (Eckhel Brothers.)

[2] The coarser kinds and clippings are also used quite extensively for stuffing mattresses, carriage cushions, etc., in place of hair.

months. A more limited fishery, however, is still carried on at Anchor Keys, some thirty-five miles outside of Cedar Keys, and in other places where the water is stiller, clearer, and warmer than nearer shore.

The commercial grades coincide very closely here and in Europe, but it is quite easy to show that each of them may be considered a distinct species if one has an inclination to multiply in this direction. The grades are Glove Sponge (*Spongia officinalis*), sub-species *tubulifera*, Wool Sponge (*Spongia equina*), sub-species *gossypina*, and Yellow and Hard Head, both under the name of (*Spongia agaricina*) sub-species *corlosia*. These correspond with remarkable accuracy to the three principal grades of commercial sponges in Europe. These are the Bath Sponge, *Spongia officinalis*, the Horse Sponge, *Spongia equina*, and the Zimocca Sponge, *Spongia agaricina*. This result, in which three species appear on both sides of the Atlantic as representing alone the marketable qualities of the genus Spongia, becomes of double interest when these varieties, or local species as they might be called, are compared one with another. It is then found that the aspect of the surface is closely similar in each of the three; that subspecies *tubulifera* represents *Spongia officinalis*, sub-species *gossypina* offsets *Spongia equina* in the same way, and lastly, sub-species *corlosia* has the same relation to *Spongia agaricina*. The general comparison of the figures in the plates will show this well enough; but in order to make it more convincing that such a relationship is not the result of an artificial arrangement, it becomes necessary to describe some of the facts more at length.

First, their similarities of surface and aspect are precisely the same as those which experience has led me to adopt in the designation of species in this group. Thus if they had occurred in different parts of the same sea, I should not have hesitated to unite them.

Secondly, their differences can be accounted for by the difference in habitat, and are of varietal and not of specific value, according to the accepted use of the term species.

For establishing the first proposition, it is only necessary, as previously remarked, to consult the descriptions of the genus Spongia and the figures. The second proposition, however, requires more attention.

The whole group of Keratosa is confined to seas, in which the differences observable between the winter and summer isotherms are not excessive. None are found north of Cape Hatteras and the Islands of Bermuda, and doubtless a similar limit occurs to the southward of the equator; at least it is a noticeable fact that the only specimens in the Museum of Comparative Zoology are from the Island of Fernando Noronha. On the Pacific shore, Southern California and Chili are the extreme points so far known. On the opposite coast of the Atlantic they are recorded from England to the Cape of Good Hope, and also at the Island of Teneriffe. In the Indian Ocean they are found all along the east coast of Africa, at the Mauritius, and on the shores of India. They have been described from the southern part of the sea of Ochotsk, on the Asiatic continent, and specimens are not uncommon on the coasts of Australia and New Zealand. In the Pacific they have been found at the Kingmills Islands, and Hawaiian Islands. The extreme outlying form to the north on both sides of the Atlantic is the excessively coarse *Dysidea fragilis*, with its fibres loaded with debris. Those from the Cape of Good Hope and Southern Australia also belong to the coarser genera. The species cited by Miklucho Maclay from the sea of Ochotsk, seems to be one of the Phyllospongidæ, but there is no analysis of the characteristics of the skeleton, only the external form being described and figured in his article on the sponges

of the North Pacific, (Mémoires de l'Acad. Imp. de St. Petersburg, Vol. 75, No. 3.) It would seem, therefore, that the finer skeletons of the Keratosa, those of the genus Spongia, were only to be sought in the intermediate zone, where the waters are of equable and high temperature. Again, in examining the species of this genus with relation to each other, it becomes equally evident that they are finest and most numerous in archipelagos, or off coasts which are bordered by large numbers of islands, or long reefs, or in sheltered seas. I am informed by Mr. Gurdon Saltonstall that the sponges near Nassau lie on reefs very much exposed to the action of the waves, often thirty miles from land, and always in currents, sometimes running three or four knots an hour. Such currents are usual wherever groups of islands confine the tide water within certain definite channels, and they have also the effect of concentrating the floating food in the channels, or wherever tides meet. Both of these conditions are essential to successful sponge growth, namely, a continuous renewal of aërated water and a plentiful supply of food, and are probably partly the cause of their abundance in such places. This entirely agrees with my own observations upon many species on our own coast of Chalininæ and Halichondrida. Constant reference to physical influences is also noticeable in the map prepared by Von Eckhel, and in the method of classification adopted by him. The marketable qualities are described as "sorts," and the different "sorts" designated by letters as "sort A," "sort B," and so on. These sorts he has found it most convenient to arrange according to localities, and thus under some "sorts" we have all the three species represented; all, however, from the same place, and all having some local peculiarity which makes them either of superior or inferior quality. The author also frequently refers to the slimy character of the bottom as a reason for inferiority, or dark color. On our side of the Atlantic this is also shown by the great difference in point of color and fineness between the Nassau and Key West sponges. The former are lighter colored, finer, more elastic and more durable than the same species at Key West, where the color is so dark that it designates at once the locality from which the specimen came. Again, the shallow water sponges are coarser than the deep water forms. This is probably due, in part, as in other species, to the quantity of sediment, which is of course less in deep than in shallow water, as, for example, at Key West in the winter time. I am informed, in this connection, by Mr. Saltonstall, who made inquiries for me among the spongers, that no fine qualities of any sponges are found within the limits of the milky water, but all the finer qualities of the marketable kinds in the deepest water in which the species occur, except, perhaps, in the case of the Reef sponge. Glove, Reef and Hard-head, are fished in shallow waters, greatest depth two fathoms, and the other, and generally finer marketable varieties, from two to five fathoms. This fact also explains, in a measure, but not wholly, the greater coarseness of our own sponges as compared with the European. For though it may be assumed from the examination of the skeletons that Mediterranean sponges are much less exposed to turbid waters, and though it may be shown by the microscope that the primary fibres contain less debris, this does not wholly explain their greater fineness and elasticity. I think that we may attribute this either wholly or partly to peculiar climatic conditions.

The Mediterranean Sea is divided by observers into two great basins, the Western and the Eastern. Dr. Carpenter's recorded soundings on H. M. S. Porcupine and Shearwater[1]

[1] Proc. Royal Society. Vol. xx, p. 578, 1872.

show considerable difference in the temperature of the water during the months of August and September in the two basins. At the depth of thirty fathoms, the limit of bathymetrical distribution for the Spongiæ, the water of the Western Basin was 63° to 66° Fahr., while in the Eastern Basin it was from 66° to 68°. Dr. Carpenter's observations were made during the prevalence of very hot weather in the Eastern Basin, and in the western part of the Eastern Basin. Fortunately, however, other observers have remarked the higher general temperature of the Eastern Basin. Capt. T. Spratt[1] and Capt. Nares[2] also give tables from which we copy and deduce (p. 489) the following temperatures for the thirty fathom line.

It will be readily seen by the table that the conclusions of Dr. Carpenter, that the Eastern Basin was relatively to the Western of a somewhat higher temperature, is true of corresponding seasons of the year, but is subject to certain local variations, as pointed out by Capt. Spratt's observations, near Crete, where he finds 59° at 50 fath. in September, against 59°.7 in August in the Western Basin, and 56° near Malta, in September. It is probable, also, that in this locality the winter temperature at thirty fathoms would average very nearly what it does in the Western Basin at the same depth, since even in June, with the air at 80°, it holds a temperature as low as 68°, within 5° of the extreme western station of Carpenter. In the Grecian Archipelago, also, the deep water temperature of 56° comes up to the one hundred fathom line, and shows again an approximation to the lower temperature of 55° near Malta, and at Station 1 of Carpenter at the same depth. This is important to the present subject, since in the Grecian Archipelago one of the finest qualities of *Spongia officinalis* is found, but *Spongia equina* is rare, and of an inferior quality, according to Von Eckhel. Though in the soundings this cold water does not reach the fifty fathom line, it becomes quite probable that in the winter months it very often rises as high as this.

Admiral Smyth's[3] work on the Mediterranean, which also confirms these remarks, is very instructive on other points, which it is necessary to consider before proceeding farther. This author states that the average difference between the temperature of the surface water to the depth of eight fathoms, and the temperature of the air, both taken at the same hour, is about 3°.5 colder for the summer, and 1°.5 Fahr., warmer for the winter. This appears to be very small, but it will be observed in the table that in summer the difference must frequently be very slight between the surface and the air where the thermometer stands near 70°, or in winter, when it is about 60°.

The difference of temperature between the Eastern and Western Basins of the Mediterranean may possibly help us to account for the peculiar distribution of the commercial sponges, and their partial absence from the Western Basin. They are found on the Dalmatian shore of the Adriatic, as far as Triest, and on the shores of Tunis, Barbary and Morocco, as far as Ceuta, but not elsewhere in the Western Basin. If we take into consideration the observations of Admiral Smyth with regard to the relative temperature of the air and surface water, and remember that the latter, to the depth of 30 fathoms in a comparatively still sea, like the Mediterranean, must be constantly influenced by the seasons whenever there are no constant currents, and no proximity to a large body of colder and deeper water, these difficulties will, in a measure, disappear. The winters along the shores of Spain, France and Italy, are quite severe as compared with the corresponding periods

[1] Peterm., Geogr. Mittheil., 1862, p. 131, and Nautical Magazine.

[2] Proc. Royal Soc. Vol. xx, p. 97.

[3] The Mediterranean. London, 8vo. 1854.

	E. of Rhoades, Aug. 25.	Greek Archipelago, July 25.	Near Crete, Sept. 29.	Near Crete, June 13.	West of Alexandria, April 16.	N. E. of Syrtis, Station II., Oct. 11.	Syrtis, Feb. 21.	Syrtis, Feb. 27.	Egypt, Nov. 15.	Egypt, April.	S. E. Malta, Station III., Oct. 3.	E. of Malta, Station II., Sept.	Between Malta and Tripoli, Nov.	Near Straits of Gibraltar, August.
Air.	88°.0	86°.0	76°.0	80°.0	68°.0			56°.0						
Surface.	82°.0	78°.0	75°.0	73°.0	62°.0	79°.0	61°.0	60°.0	73°.0	63°.0	80°.0	77°.0	69°.0	74°.5
30 fath.	78°.5	71°.5	68°.0	68°.0	61°.5	75°.5	62°.0	60°.5?	71°.0	61°.5?	66°.2	60°.0	62°.0	63°.0
50 fath.	77°.0	69°.0	59°.0	63°.0	60°.0?	67°.0	62°.0	61°.0	68°.0	61°.0	61°.0	56°.7	62°.0	59°.7
100 fath.	73°.0	56°.0+	56°.0+	59°.7	59°.5?	59°.5	62°.0	61°.5	62°.5	59°.5	58°.5	55°.5	62°.0	55°.1
200 fath.				59°.7	59°.5?	58°.5	62°.0?			59°.0	56°.5		62°.0	
270 fath.										59°.5				
290 fath.							62°.0							
295 fath.													62°.0	
300 fath.					59°.5	57°.0								
500 fath.						57°.0								
586 fath.													55°.0	
1240 fath.		a		59°.5										
1156 fath.												55°.0		
1650 fath.											56°.0			
1970 fath.						56°.7								

on the shore of Morocco and Barbary. According to Berghaus, at Palermo, in Sicily, the average winter temperature is about 52°.3 Fahrenheit, 11°.3 Centigrade ; at Naples, the next warmest locality noted in the Western Mediterranean, it is 49°.2 Fahr., 9°.8 Cent. All the more northerly parts on the coasts of Italy, France, or Spain, have a lower average winter temperature, including Cagliari, on the southern shore of Sardinia.

According to Admiral Smyth, the lowest aerial temperatures recorded were 36° in Sicily and 34° in Sardinia, and he gives for the "middle latitudes" of the Mediterranean a variation of from 50°.1 to 44°.3 for January, an isotherm of 46°.2. This of course refers to the Western Basin, where these observations were made, and accords quite closely with the aerial isochryme of 50°, as laid down by Schouw, which runs a little south of the central parallel of 40° in the Western Basin. With an aerial isotherm of 46° or an isochryme of 50°, it may be assumed with great probability that the water at the depth of 30 fath. would not be above 55°, since even in summer, at this depth, near Malta and in the extreme western station of Carpenter, the temperature does not range above 63°, and remains at 55° at 100 fathoms in two localities. It will be seen farther on that this temperature, though lower than that of the coasts of Barbary and Morocco, is not sufficient of itself to account for the absence of commercial qualities of the Spongiæ from Sicily, Sardinia, and the southern coast of Spain.

The more northerly parts on the southern shore of the same basin have a considerably higher average; thus Algiers, according to Berghaus, has an average winter temperature of 54°.3 to 61°.7, or about 58°, which is probably the correct mean, and in Schouw's map by Berghaus, it stands nearly upon the isochryme of 54°.

Tunis and Cairo, to the westward, have still warmer climates. Admiral Smyth gives the following temperatures; at Algiers, 86°.8 – 41°.5; at Tripoli, 92°.5 – 51°.2. No mention is made in any authority to which I have been able to gain access of such cold weather as undoubtedly is not infrequent even in southern Italy, Sicily and Sardinia, and the whole shore from Tripoli to Syria lies close to the isochryme of 57°.

The condition and inferior quality of the sponges on the Algerine coast show that here we have reached the extreme limits of their habitat, and the average winter temperature of the surface water, according to Admiral Smyth's allowance for variation, would be 58° + 1°.5 = 59°.5, a result which accords very closely with Schouw's map, and the observed deep water temperatures in the Western Basin and near Malta, at 100 fathoms. These calculations would seem to be very favorable to the view that both the bathymetrical and the geographical distribution of the Spongiæ were limited by the minimum temperature of 55°, but there are other localities to be considered.[1]

The area of the earth's surface drained by the rivers which flow into the Black Sea, amounts, according to Carpenter, to 939,000 square miles, while its own area, and that of the Azoff Sea, is only 172,500 square miles, and its connection with the salt waters of the Mediterranean is limited to the narrows of the Bosphorus. Under these circumstances it is not remarkable that its salinity or density, as compared by means of its specific gravity with that of ordinary sea water, should vary from 1.012 to 1.014, and be less than half that

[1] Admiral Smyth is probably in error with his deep sea temperatures. The discrepancy between his statements and those of Spratt and Carpenter cannot be otherwise accounted for; the average being, according to Smyth, 42° to 43° below 180 fath., while 55° is the lowest given by the other authorities.

of the Mediterranean, which in the Western Basin varies from 1.0280 to 1.0284 in the neighborhood of Sicily, and is even denser in the Eastern Basin, rising between Malta and Crete from 1.0284 to 1.0288. If this want of an average amount of salinity did not account for the absence of the genus Spongia, and possibly all the Keratosa from the Black Sea, the temperature of the water would, the winters being exceedingly severe. The isotherms of the summer months, according to Carpenter,[1] range between 70°–80°, while in the winter the variation is 30°–40°. This extreme cold is due to the sharp northeast winds which come over the snow-clad plains of Russia from the Arctic regions. Ice is therefore very abundant along the northern shores in winter, and the temperature of the water probably falls quite low, since in the temperature taken by Commander Wharton,[2] of which unfortunately only one observation is recorded as made in October, the water was only 62° to a depth of 30 fathoms, then a cold current of 54°, and below this again the thermometer rose to 60°.

If either the temperature or density of the water had been exceptional, we might have gained some additional information, but as it is, we cannot assume that either cause would have been sufficient to account for the absence of the Spongiæ from the Euxine. According to Carpenter, in his articles on the Mediterranean and Black Sea, there is a strong current continually flowing at the depth of twenty fathoms from the Mediterranean into the Black Sea, and a return surface current from the Black Sea into the Mediterranean. The sponges occur necessarily in the shallower waters of the Sea of Marmora, since they are said by Von Eckhel to be fished for mostly with the harpoon, and are probably exposed more or less to the influence of the surface current. Under these circumstances they must very often be able to endure a degree of cold during the winter, and an amount of change in the density of the water, for which it becomes difficult to account, even taking into consideration the inferior quality of their skeletons. It is possible, however, that the water of the northern part of the Black Sea may not affect the temperature of the southern part to such an extent as would at first sight appear probable, and that, notwithstanding the lower temperature of the northern shores, the general temperature of the surface water during the winter immediately east and west of the Bosphorus may not fall below 55° as a minimum. The average of the aerial winter temperature of Constantinople, according to Berghaus' map, is about 40°.6, but this does not agree closely with the lowest temperature recorded by Admiral Smyth of 53°.4. It does not seem probable that this comparatively high average winter temperature could be maintained if the waters of the Black Sea and Sea of Marmora were to become very cold in winter, but it is a much lower temperature than is found on the Algerine coast. The aerial isochryme, however, is as low as 42°.5, according to Schouw's map.

The northern shore of the Ægean Sea and the eastern shore of the Adriatic Sea are populous with sponges, and yet the former throughout its whole extent, and the latter from Ragusa to Istria, have nearly the same average winter temperature, and possess a colder climate in winter than the coasts of southern Italy or Spain, where no Spongiæ exist. Again, upon consulting the invaluable little Eckhelian pamphlet, we find that the sponges correspond in quality to this climatic change. The sort found at the head of the Ægean is said to be the *Spongia officinalis* alone, and to have a "heavy, hard, close, very hairy skeleton, often containing slime," and it is farther added that it is not much liked, and is

[1] Encyclopedia Brittanica, ninth edition.

[2] Proc. Roy. Soc. Vol. xxi, No. 145, p. 387.

usually fished with the harpoon. The same species exists also alone at corresponding localities along the shore of the Adriatic, and at the extreme locality, the Island of Istria upon the limit of its distribution, it is said to be very rare, the form to be ugly, the skeleton hard, the color dark. Farther south, along the Dalmatian coast, it becomes abundant, finer in texture and of a lighter color, but it is still inferior to the more southern or Levantine variety. In considering such classes of facts, it must also be borne in mind that the habitat of a certain sort or variety may largely determine the quality of the skeleton, even where the temperature may be very favorable. Thus to the south of Quarnero, among the islands, a much better quality of *Spongia officinalis* occurs than in the milder sea about the Ionian Islands, which, as Eckhel remarks, is probably attributable to the slimy character of the bottom.

A sufficient reason for the absence of the Spongiæ on the Italian shore can be found in its physical characteristics. The Adriatic is a comparatively shallow sea, and according to Admiral Smyth's soundings, the greatest depth between Istria and Venice is 20 fathoms, and in the centre of the sea to the southward, only 500 fathoms. A constant current from the south passes northward along the eastern, and southward on the western shore. It is clear and probably warm in its passage north during the winter from the south, and it seems probable that this current parts with much of its heat in the shallower waters of the Gulf of Venice, falling, perhaps, to a temperature which would prohibit the extension of the Spongiæ beyond Trieste. For if we apply Admiral Smyth's rule to the correction of the average winter temperature for all these more northern localities, the Sea of Marmora, the northern shore of the Ægean and Gulf of Venice, we find that the average temperature of the water for these places would be represented by 56°.5 + 1°.5 = 58°. But the isochryme of 42°.5 passes directly through the Sea of Marmora, the northern part of the Ægean and Ragusa, leaving Istria considerably to the north with an isochryme of about 39°.

It does not seem at all probable that any species of the true Spongiæ can live in surface water which is affected for any length of time by such a degree of cold, and the only explanation to be offered of their existence at such northerly points as Istria, must lie in the warmth of the current from the south. If this is taken into consideration, and it is also observed in the table how great the variation is between the air and water during the winter season on the coast of Syrtis, the water being fully 16° warmer than the air; and how great the variation is also in summer, when the difference is sometimes 10°, as noted by Dr. Carpenter, the air being 90° and the sea 80°; it becomes evident that the water of the Mediterranean, like that of other seas, responds very slowly to extreme changes of temperature. The Adriatic current alluded to not only probably retains a large part of its original temperature in its progress along the coast of Albania and Dalmatia, but even at Istria we should expect to find at least 15° difference between the extreme isochrymal of the air and that of the water. If this is correct we should reach the temperature of 39° + 15° = 54° as an isochrymal at Istria, and 42°.8 + 15° = 57°.8 as the probable isochrymal of the water at Ragusa. A similar result can be obtained also from the extreme aerial isochrymal of the Sea of Marmora, if it is worth while to make a calculation in such a peculiar locality, namely, 42°.5 + 10° = 52°.5, as an isochrymal for the water. These being the most northerly or most unfavorable points at which the Spongiæ are known to exist, we cannot be far wrong in assuming from the facts and inferences above cited, that in a comparatively quiet, clear sea like the Mediter-

ranean, they are never for any length of time exposed to a lower degree of cold than 50° to 55°, and that this produces a very unfavorable effect upon the quality of the skeleton.

This of course directly negatives the conclusions drawn from the conditions found to exist on the southern coast of the Western Basin, as contrasted with those of Sardinia, Sicily, and southern Italy, and it becomes evident that the temperature alone cannot be the cause of the absence of the Spongiæ from these shores.

Locally we can say with some degree of probability, that the temperature and the fresh waters of the Po, with the vast quantity of silt which is carried by it to the sea, and distributed along the shore to the southward, have proved to be barriers in this direction. When, however, the attempt is made to explain why they are absent from all the other northern shores of both the islands and the coasts of the Western Basin, all single causes seem to fail, and I can only suggest the following, viz., that, where the limits of temperature are neared, the absence of small islands, or very slight local peculiarities, may occasion the absence of *the commercial sorts*. It must also be remembered that it is not distinctly known that all are wanting; our information is limited wholly to the commercial sorts, and the other coarser and non-marketable varieties have not yet been systematically hunted for by naturalists.

The finest sponges in the Mediterranean, those of the Levant and off the Syrian and Tripoli coasts, are found between the average aerial winter temperatures of 63° and 70°, and the isochrymals of 50°–57°, and the table (p. 489) shows that at no time of the year are these, which, as stated by Von Eckhel, occur in the deeper water at a distance from the coast, probably exposed to a lower temperature than 60°.

This repeated approximation of all calculations of the surface temperature, however made or wherever made in the winter, to a marine isochrymal of 55° to 60°, although not so convincing as a series of actual observations, appear to point this out as probably a close approximation to the actual isochrymal which limits the geographical distribution of the prime qualities of commercial sponges, and this view derives great additional support from the fact, already stated, that this is the constant temperature of deep water in summer, and the probable isochrymal at the depth of 30–50 fath. in winter in a large part of the Mediterranean.

I am indebted to the U. S. Signal Service Office for a series of tables giving the average temperature for all the months in the year of the surface water of St. Marks, on the west coast of Florida, lat. 28° 55′, long. 84° 07′; Punta Rossa, also on west coast, in lat. 26° 29′; long. 82° 10′; Key West at the extreme south, and Jacksonville on the Atlantic side. The following is a copy of the average temperatures of all the months in the year. The St. Marks' column, however, is taken from only one complete series of observations; while the Punta Rossa, Key West and Jacksonville averages are all deduced from three years of continuous observations.

The isotherm for the month of January at St. Marks is 63°.5, for Punta Rossa, 68°.8, and for Key West 73°. Anchor Key and Cedar Keys, famous localities for spongers, are between St. Marks and Punta Rossa. These temperatures differ but a few degrees from the aerial isotherm, which is at St. Marks 5°, at Punta Rossa 10°, and at Key West 4°.5 colder than the water, whereas in summer the temperature of the air at these localities is respectively 1°.5, 6° and 5° warmer than the water. The marine isotherm for the month

APPROXIMATE AVERAGE TEMPERATURES.[1]

MEAN OF MAXIMUM AND MINIMUM.

	St. Mark.	Punta Rossa.	Key West.	Jacksonville.
January	63°.5	68°.8	73°.0	58°.0
February	63°.5	71°.0	73°.8	60°.7
March	63°.5	74°.3	75°.8	68°.0
April	69°.0	75°.5	76°.5	72°.3
May	74°.0	81°.9	81°.2	79°.2
June	76°.5	82°.7	84°.8	85°.3
July	78°.5	86°.0	85°.0	86°.8
August	78°.5	86°.0	82°.8	85°.8
September	75°.5	87°.5	84°.2	82°.5
October	67°.5	79°.5	80°.2	74°.8
November	64°.2	75°.2	76°.8	67°.5
December	62°.0	67°.7	72°.5	59°.5
Yearly ave'ge	69°.7	78°.0	78°.9	73°.4

of January of 68°, was traced by Dana[2] only as far as Cape Carnaveral, but, as this table shows, it probably begins again on the west side, at or near Punta Rossa, and bending northwards probably includes nearly the whole area of the Gulf of Mexico. The whole of the region favorable for the production of the commercial qualities, lies between St. Marks, on the coast of Florida, with an isotherm for January of 63.5, and the equatorial isotherm for January of 80° ; south of this equatorial isotherm, however, the limits have not been ascertained, the data, both as regards the sponges themselves and the temperature, being deficient. Although the non-marketable varieties occur at several places in the northern zone, such as Vera Cruz, Cuba, and so on, the finer sorts are only found along the west coast of Florida, among the Keys, and in the insular waters of the Bahama and Carribean Islands. Their absence from a large part of the shores of the Gulf may be attributed to the sandy or soft character of the coast, to the effect of the silt of the Mississippi and to the absence of outlying islands. The absence of the commercial kinds from the Atlantic shore may be explained in a similar manner by the frequently open and sandy or clayey character of the entire coast northward to New York, which would effectually prevent their existing even in the most sheltered bays and nooks. Besides this the aerial isotherm of January does not represent the unfavorable conditions of the climate, since at long intervals very severe winters occur as far south as Chesapeake Bay, when the surface water must become very much chilled by the large amount of ice formed in the numerous smaller bays, rivers and harbors, north of Cape Hatteras. The severest test of the ability of the Spongiæ to withstand the climate would therefore be shown by the average of the minimum or isochryme of the water for January, for several successive years, taken near shore, which must necessarily be very much below that of the average temperature or marine isotherm for that month at even a short distance from the Atlantic coast, on account of the inshore or return cold current from the north, which prevents the influence of the warm waters of the Gulf Stream from reaching the surface waters of the coast. That the coarser varieties of the commercial sponges can survive even these adverse conditions to a certain extent, is shown by the specimens of *Sp. agaricina*, sub-species *corlosia*, var. *divisa* from Stono Inlet, South Carolina.

[1] These were taken on the bottom, at depths varying from seven to twenty feet, according to the station.

[2] Corals and Coral Islands. New York, 1872.

The finding o these specimens and the considerations above noted, induced me to apply again for assistance to Gen. Myers, Chief Signal Officer, for the temperatures during the months of January and February, at the stations along the Atlantic coast south of Cape Hatteras. The records, which were immediately forwarded, and are in the accompanying

TEMPERATURE OF WATER FROM OBSERVATIONS TAKEN AT BOTTOM.

	WILMINGTON, N. C.		CHARLESTON, S. C.		SAVANNAH, GA.		JACKSONVILLE, FLA.	
	MAXIMUM.	MINIMUM.	MAXIMUM.	MINIMUM.	MAXIMUM.	MINIMUM.	MAXIMUM	MINIMUM.
January, 1874,	53°	42°	—	—	54°	44°	59°	50°
February "	54°	42°	—	—	—	—	65°	57°
January, 1875,	49°	40°	53°	45°	53°	43°	62°	56°
February "	50°	41°	56°	42°	57°	42°	64°	55°
January, 1876,	54°	47°	68°	48°	58°	46°	68°	56°
February "	55°	49°	57°	41°	56°	49°	66°	58°
January, 1877,	51°	41°	54°	43°	58°	37°		
Average maxima and minima for January	51°.7	51°.7	58°.3	45°.3	55°.7	42°.5	63°.0	54°.0
Isotherm for Jan.	46°.3		51°.8		49°.1		58°.5	

table, give the strongest support to the idea that the temperature has probably more influence than any other cause in limiting the distribution of the Keratose sponges to the more southern localities. The commercial qualities being in all cases shallow-water animals could not, without great difficulty, spread to the northward from the Key West region to the region along the Atlantic coast of Florida; they would be exposed after passing Jacksonville, not only to all the unfavorable conditions of the open sandy shores, but also after a few fortunate forms had gained the inlets, the general absence of favorable holding, and perhaps feeding grounds, would be supplemented by an average temperature approximating during the month of January to the unfavorable limits previously traced in other localities. North of Jacksonville the temperature falls below 58° very rapidly, becoming very unfavorable to the existence of these forms; thus at Savannah it averages as low as 49°. Here there is evidently some local disturbance, since the regular rate of decrease northward would make this some degrees higher. At Charleston, the January temperature is only 51°, and at Wilmington, 46°. These averages, and the recorded isochrymals, are somewhat remarkable confirmations of the deductions previously made in the Mediterranean and

along the coasts of Europe and America, with regard to the temperature limiting the northern spread of the genus Spongia.

It was entirely upon this ground that I first began to doubt the accuracy of the marine isothermals for January of 62°, 56°, 50°, which are laid down on Prof. Dana's map as coming to a focus at Cape Hatteras. These should be carried down the coast, deviating inside or west of the Gulf Stream to the southward, as does the more accurately drawn isotherm of 68°, and should be drawn nearly parallel to the coast to some point south of Jacksonville for 62°; to some point south of Savannah, probably Altamaha Sound, for 56°; and to Cape Roman, north of Charleston, for 50°. This same rate of decrease would bring the line of 44°, which ends at Cape Cod on Prof. Dana's map, down the coast to a point a little south of Cape Lookout, on the shore of North Carolina, and reduce the average temperature of the water at Cape Hatteras, during the month of January, to about 40°.

This appears to be the result of the cold inshore current, which during the winter probably comes closer inshore, and combines with the atmosphere in affecting the surface water. Such a current has been traced by the United States Fish Commission to the south of Cape Cod, even in the shallow waters of the Vineyard and Long Island Sounds, and is constantly referred to in the reports of the United States Coast Survey as coming to the surface farther out to sea. This return current is crowded into a smaller space as it runs southward, and would therefore be likely to exercise a much more important influence proportionally to the winter south of Cape Hatteras than to the north of that Cape, upon the surface waters in January. Whether this is so or not, it is very remarkable that the selected limit for the spread of all Keratose forms northward on the American Coast was Cape Hatteras, and it now turns out that the temperature of the surface water must be nearly the same as it is along the northern limit of distribution of the same forms on the European side, namely, a January isothermal of 40° on this side as compared with 41° on the other.[1] It ought to be observed here also, that Charleston is the most northerly point at which a Keratose form has actually been found. This species, according to Prof. McCrady's verbal description, must have had a very coarse skeleton allied, if not identical, with *Dysidea fragilis*, which, as previously observed, is the most northerly species on the European side also. It is possible, therefore, that the generally unfavorable and sandy character of the coast may have limited the distribution to a point as far south as Charleston; but it would be unsafe at present to adopt this view, Cape Hatteras being the natural limit of the entire littoral fauna.

Dr. Buist[2] states that the temperature of the water in the Red Sea, between Aden and Suez, varies between 65° and 85°. The same authority subsequently published[3] a long account of this region, accompanied by tables of temperatures from which the following remarks were taken. The density of the water, except in the Gulf, was not excessive, averaging about that of ordinary sea water except in the Gulf of Aden. The transparency and purity of the water was very great, and this might also be remarked of the waters of Florida and the Bahamas in the summer. Ten feet below the surface the temperature at Suez does not fall below 70°, or the air lower than 72° in January or February, and the heat in summer is excessive, 80°, 82°, 92°, being not infrequently recorded at Aden, and 80°,

[1] See Dr. Carpenter's map. Proc. Royal Soc. Vol. xx.

[2] Trans. Bombay Geogr. Soc. Vol. ix, p. 39, 1850.

[3] Trans. Bombay Geogr. Soc. Vol. xiv, p. 3, 1859.

83°, 86° at Suez. These great heats are also occasionally reached on the coast of Florida; at Punta Rossa and also at Key West, it is sometimes 90° or 92°.

Capt. Pullen's[1] soundings give remarkably low temperatures for the depths of the Red Sea. 44° at 1889 fath., surface 81°.5; 43°.5 at 1500 fath., surface 82°; 45° at 1200 fath. with surface 81°.5. The northern part of the Red Sea, where, according to Von Eckhel, most of the commercial sponges are found, has an aqueous isochrymal of about 70°, and this accords with Carpenter's remark in the work above quoted, that the waters of the Red Sea are uniformly 71°, but not wholly, since he has inferred that this is the mean temperature at all depths, which cannot possibly be the case unless all other observers are in error.

The sponges of the Red Sea, according to Von Eckhel, are inferior to, and rarer than, those of the Mediterranean; he compares them to the Zimocca variety, describing the skeleton as brittle, entirely red, and very dark at the base. Not having seen any specimens unquestionably from this locality, I cannot compare them with the Key West and Australian varieties; but they are evidently, so far as quality is concerned, more like the coarser Zimocca sponges of the Mediterranean, since Eckhel describes them as mixed with these in the trade. The extremely hot temperature of the Red Sea does not, therefore, when acting in perfectly clear water, produce so great changes as when the waters are more loaded with sediment, as in the shallows of the Florida coast, or else these specimens could not be sold commercially even in the company of the inferior Mediterranean qualities.

I have seen but few true Spongiæ from Australia. These are coarser than their congeneric form, *Spongia discus*, and, like this species, have an excessively dark, rough skeleton. The neighborhood of Sydney, where they were collected, lies under the marine isochrymal of 62°, as laid down by Dana, and the coast is open and apparently unfavorable for the growth of the commercial sorts. This, and the aspect of the specimens, leads me to think that they were beach specimens which had drifted from the coast of Queensland, which, judging from the descriptions of voyagers, must be exceeding favorable, inside of the great boundary reef, for the growth of the true Spongiæ. The collection of the Keratosa received from Dr. Farlow, was made at Port Phillip, near Melbourne, on the south coast of Australia, and though the genera are well represented, there are among them only three specimens allied to true Spongiæ; these have coarse, loosely constructed skeletons, and I have been obliged to propose a new generic name, *Carterospongia*.

Although the distribution of the Spongiæ is not limited by the same isochrymal as that demonstrated for the reef building corals by Prof. Dana, namely, 68°, the association of these with the Spongiæ having coarse and inferior skeletons cannot be a matter of accident. The coral reefs afford good holding ground for the bases of the colonies and protection from the excessive surf of ocean shores, while they grow in water, the remarkable clearness of which to a considerable depth is the constant subject of remark. These are undoubtedly favorable conditions, since they are common also to the Mediterranean waters. The great quantity of calcareous sediment, however, which is churned by the waves in the winter on the borders of a coral reef, is not present in the Mediterranean; and the average temperature, also, which is very much higher than that under which the finest sponge skeletons are produced in the Mediterranean, cannot be considered as

[1] Trans. Bombay Geogr. Soc. Vol. XIV, p. 44, 1859.

favorable. These last, then, are probably the direct causes of the inferiority of the skeletons of the commercial varieties found in this association.[1]

These views, as a whole, therefore depend for confirmation upon the accuracy of the calculations with regard to temperature, and upon the following facts: that the inferiority of the skeleton, which is common at Key West, with the same isochrymal as the Red Sea, is not found to the same degree in the sponges growing in the clearer waters of the latter; that the coarsest quality of all the Mediterranean sponges, the "Gerbis sort," and other coarse "sorts," grow in localities along the coast, where they are most subject to the action of suspended matter in the water; but all of these are, however, on account of the clearness and medium temperature of the Mediterranean waters, as compared with those of other seas, of much finer quality; that the coarser kinds of the same quality or variety grow nearest the shore, and the finer kinds in deeper water, and also according to Nassau spongers, are more apt to occur upon marly ground, where the sediment is finer than upon other kinds of bottom; and lastly, that the inverse ratio between the quantity and even the prevalence of different kinds of sediment, such as sand grains or spicules, and the resiliency and flexibility of the fibres may be demonstrated with the microscope in any series of specimens.

It may be well to notice, however, that the openness, or apertion, which usually accompanies and appears to correllate with coarseness of the fibre, cannot be accounted for in this complicated way, but, strictly speaking, must be considered as one of the elements of inferiority which invariably accompanies a skeleton having a loose microscopical texture or mesh, and harsh, inelastic, or easily torn fibres, but is also, though rarely, found in skeletons of very fine quality, especially at an early age. Thus it may be said, that it is undoubtedly a common characteristic of all the inferior qualities of Mediterranean, and of all the Carribean commercial sponges, without exception, which, though they may have very fine or very coarse or inelastic fibres, are always permeated in the interior, and have the surface also cut up, by larger and more numerous canals than the corresponding Mediterranean species. The Australian species of the genus Spongia, though coarser in fibre than the Carribean forms, are equally open, and are harder when dry than any of the former, except certain rare varieties of *Spongia agaricina* and *Spongia discus*. In this connection it may be appropriate to call attention to the forms, all belonging to the unmarketable varieties of the genus Spongia which have been found in hot climates, as for example, at the Mauritius and the Hawaiian Islands with an isotherm for the coldest months of 74°, Kingsmill Islands and Feegee Islands with one of 80°, at various places in the Bay of Panama and Gulf of Mexico with isotherms for January of from 74° to 80°. The extremes of temperature are represented at Stono Inlet, South Carolina, with a marine isochryme of about 51°, and Sydney, Australia, with one of 56°. The evidence afforded by these, all of which have very open, coarse, and brittle skeletons, therefore confirms the opinion, that this characteristic of apertion may be with great probability attributed perhaps exclusively to the influence of an unfavorable temperature, which, if the limits suggested in this paper are correct, might be either the amount of cold indicated by an

[1] What effect the superior density of Mediterranean water may have, it would not be possible at present to say, the data being insufficient, but it is probably very slight. The chemical composition of the water has also not been sufficiently investigated, and this may prove to be of greater importance, since the variation is probably much greater in this respect, especially in the vicinity of coral reefs.

isotherm for the coldest months of about 50°, and possibly lower to some as yet undecided limit, or the equally injurious heat shown by an average for the same month of about 65° and upwards, to 80°.[1]

There is a darkening of the color of the fibres about the base, and frequently of the whole sponge, which may occur with any of the inferior qualities in any cold climate, or unfavorable situation, as at Istria, and varies also with the age and size of the specimen. These influences, however, never produce so marked an effect as in a hotter climate, nor does the deterioration of the fibre and of the density of the skeleton go so far; nevertheless, the Nassau sponges, which are lighter colored than the Gerbis sponges, and the remarks above on the influence of suspended matter near the shore, seem to point out very conclusively, that heat does not control the color entirely, though it may largely influence it.

Another point in this connection is, that the deepest color is always in the interior, and the lightest colored parts are external, in the position most exposed to the action of light; and this, though not necessarily, is probably the hottest part of the organism during the heated term of the year in the shallower waters, where the darkest colored forms are mostly found. It has been suggested by Eckhel that this coloration was due to the presence of iron in the sediment or sea bottom, but this could hardly be the case in the vicinity of coral reefs. In fact, dark internal coloration appears to result from, or correllate with, the deterioration of the skeleton as an internal change in structure, which varies with the species, the age and the health of the specimen, and probably with the chemical composition of the fibres themselves.

If we now, in conclusion, turn our attention to the general limits of the distribution of the Keratosa as a whole, we find that the extreme points already mentioned may be all inclosed within a central zone extending on both sides of the equator to the isothermals for the coldest months in the year of 40° Fahr., and these, therefore, would approximately represent the natural boundaries of the circumterraneous area occupied by the order.

This distribution does not seem explicable in any way unless we assume, that the Keratosa originated in North America, and have spread in all directions from this area. This hypothesis also appears to me to explain more satisfactorily, according to our present

[1] A collection just received from the Museum of Yale College contains a specimen of *Spongia discus*, var. *auklinensis*, from the Aukland Islands, south of New Zealand, latitude about 50° 20′, and longitude 167°, and therefore if this locality is correct, affording an instance of a true Spongian form living in water, according to Dana's map, with a July isotherm of about 41°. I was led to doubt the accuracy of this isothermal line by this fact; but the examination of Mr. J. Prestwich's Memoir on "Submarine Temperatures," in Trans. Royal Soc., Vol. 165, Pt. 2, 1876, which has just come to hand, confirms Dana's view. The temperatures for the surface recorded in the neighborhood of New Zealand, on the parallel of Dana's isotherm for July of 50°, are as follows: In January, near the west coast of South Island, at 531 feet, 55°.8, and surface 63°; in Cook's Straits, surface 63°.5 to 64°.4, off the southeast coast of North Island, in February 65°.2 for surface, and 58°.7 at depth of 506 feet. Near Antipodes Island, on parallel of 49°.17 considerably to the east and a little north of Aukland Islands, the temperature of surface was found in December to be 53° in six observations by Sir James Ross, and to the southwest of Aukland Islands, near the Macquarrie Islands, in lat. 55°, long. 157°, the surface temperature in January varied between 31° – 44°, an average of 37°.5, and in latitude 57° 52′, with nearly the same longitude as the Aukland Islands, the thermometer registered 42° in December. Unfortunately these temperatures were taken during the hottest months, and thus while 41° may be a very good average for the surface in this region during the month of July, and may serve the purposes of a general map, like that of Prof. Dana, it does not accurately express the isotherm for the coldest months in the year in the shallow waters of the Aukland Islands, which appear to lie to the east and north of the colder area just south of Van Diemen's Land, and it is possible that they may average some degrees higher.

The only indubitable exception, which I have found, to this (50°) limit of temperature, occurs also in this collection — a specimen from Ft. Macon, of *Spongia vermiculata*. It is one of the coarsest, most open, and aberrant forms, but is a true Spongian, and the isotherm of the surface water for January of this locality cannot be placed higher than 44°. It is also of a light color.

knowledge, the affinities of the Mediterranean forms and of many Pacific forms, with those of the West Indian regions, and the greater number of the species and varieties found there.

Several authors have remarked the susceptibility of the sponges to physical influence, notably Bronn, Schmidt, Hæckel and Miklucho-Maclay.

Bronn remarks, in his general treatise on the sponges, as follows: — "Man hat bemerkt das die näher an der Oberfläche lebenden und den Bewegungen des Wassers, des Sandes, der Steine u. s. w. mehr ausgesetzten Arten dichter von Gewebe sind, als jene aus grossen Tiefen, oder dass sie wenigstens die geschütztesten Stationen aufsuchen. Bronn, Klassen und Ordnungen d. Thierr. 1, p. 24.

Schmidt, in "Spongien d. Adriatischen Meeres," p. 40, considers that a warmer climate increases the deposit of horny matter in the skeleton of *Scopalina toxotes*. "Das südliche Klima ist dem Uebergange der Sarcode in die Hornfasern günstig; beim Verrücken gegen den oberen Theil des Adriatischen Meeres is diese Eigenschaft bis auf den Grad verloren gegangen, welcher als Gattungsmerkmal für Scopalina aufgestellt werden konnte." This agrees very well indeed with my own researches, which show that the coarsest skeletons of the same species are in the warmest localities, so far as the genus Spongia are concerned, and it may be presumed to be true also with regard to the whole group of the Keratosa; but some species of Chalinæ have thicker fibres in the northern than in the southern forms, and we cannot therefore apply it to all the fibrous sponges, as a law having no exceptions.

Miklucho-Maclay, in commenting on the remarks of Bronn and Oscar Schmidt, agrees with them so far as they show the adaptation of the species to its surroundings, and adds, "Nicht bloss die Bewegung des Wassers, sondern auch wahrscheinlich die Temperatur, der Salzgehalt, so wie die chemische Zusammensetzung des Wassers sind Factoren welche die Skeletbildung bedingen oder verändern."

Hæckel also, in his Calcispongiæ, frequently alludes to the modifying influence of physical causes, and all of these authorities view this influence in the same way. They regard the modifications which take place as adaptations of the organization to its surroundings. Whether the modifications are to be viewed as the direct product of the agency of the physical causes themselves, or partly to the action of Natural Selection, is not so clearly expressed by them as might have been wished.

Similar researches to that in which we are now engaged have been made of late upon terrestrial animals by several authors, and notably by Mr. J. A. Allen, of the Museum of Comparative Zoology, Cambridge. The results attained by him are so much more exact and reliable, and so nearly parallel with my own, which are merely preliminary to a fuller consideration of the subject in future parts of this Memoir, that I need make no excuse for the insertion of the following abstract of the influences of environment upon mammals and birds, which has been kindly furnished by him at my special request.

"The direct action of the conditions of habitat upon mammals and birds has recently been shown, with reference particularly to those of North America, to be very strongly marked, resulting in modifications of the general size, of the coloration, and the relative size and form of particular organs. These modifications are clearly local, affecting similarly, though not always to the same degree, all, or nearly all, the species inhabiting the same areas, so that variations of a somewhat special character become characteristic of par-

ticular geographical regions. Thus there is found to be a gradual loss of color among individuals of the same species, in passing from the heavily wooded region of the eastern half of the United States to the treeless plains, and the still more arid regions beyond the Rocky Mountains, particularly in portions of the Great Basin and the desert tracts of the Gila and Great Colorado Rivers; the most pallid tints occurring where the vegetation is most scanty, and the climate most arid, — where, in short, the protective conditions as respects color are at a minimum. On the other hand, a remarkable accession of color is seen over the heavily wooded, rainy region of the northwest coast. There is again a marked accentuation of color to the southward, accompanying increased climatic humidity and a higher temperature, these conditions evidently favoring in themselves an increase in intensity, while they give rise to protective conditions, such as luxuriant vegetation and a partially overcast sky, which favor the retention of color. It is certainly found that in individuals of the same species the various shades of red, yellow, green, blue and black, become stronger or more intensified in passing from the higher latitudes towards the tropics; that dusky and black spots and bars, or other blackish areas, increase in extent, while light areas, particularly white spots and bars, become correspondingly reduced in area; and that, at the same time, there is an increase in lustre and iridescence, in species tending to such phases of coloration. There is thus a general increase in the brightness and extent of the stronger tints of coloration in the direction of the intertropical regions, where all forms of animal life, as a rule, become most brilliantly colored.[1]

"In respect to the increased size of particular organs, it is found that, especially among birds, there is a strong tendency to the disproportionate enlargement of peripheral parts in passing from the colder parts of the North America continent toward the tropics. This is particularly noticeable in respect to the bill and tail, both of which often increase in size in passing southward, either with relation to the general size of the individual, or absolutely. In birds having a short thick bill, as the finches, crows, etc., the bill becomes generally larger, while in slender-billed forms, as in some of the warblers, thrushes, wrens, the grackles, etc., the bill becomes longer, slenderer, and often more decurved. In mammals the pelage becomes shorter and harsher, with less underfur; the soles of the feet often, in great part, loose their furry covering, while in numerous well-marked instances the ears and the feet become noticably increased in size. This may be presumably considered as due to the higher temperature of the lower latitudes favoring an increased circulation in the peripheral parts of the body, and their consequent greater nourishment. Furthermore, the increase in the size of the bill and length of the tail is in the direction of the region where these parts of the ornithic organism almost universally reach their greatest development.

"In respect to the variation in size, there is generally, in both birds and mammals, a marked increase toward the northern and more elevated parts of the continent, with a few exceptions, however, of an equally marked increase in size toward the tropics. In general terms, the law of increase in size, as modified by recent researches, may be stated as an

[1] This law also applies to sponges; the brighter colored forms being generally littoral where the temperature of the water in any given locality is highest: and in the tropics there are comparatively few of the dull colored species so abundant at the north, but a prevalence of brilliant reds, greens, and yellows, with intense shades of purple and purplish brown or black. See, also, for increase of peripheral parts and coloration of Insects, "Revision of the Œdipodidæ," by S. H. Scudder, Proc. Bost. Soc. Nat. Hist., Vol. XVII, p. 482–83.

increase toward the centre of development of the species, or toward the centre of development of the group (genus, sub-family, or family, as the case may be) to which the species belongs. This increase generally amounts to from five to twenty-five per cent. of the average size of the species, but in very rare instances there is found to be no appreciable variation in size over immense areas, or throughout the entire habitat of species having a very wide geographical range. Since decrease in size so generally accompanies increase of temperature, it may be considered as possibly due to the enervating, or other unfavorable action of tropical influences upon the organism, a view strengthened by the fact that decrease in size is often accompanied by a loss of vivacity, and, in birds, a deterioration of song. In the case of the exceptional increase in size southward in North American birds and mammals, it is always found to occur in groups which attain their maximum development, both as respects the number and the size of the species, in intertropical latitudes, where of course such groups find their most favorable conditions of existence; just as increase of size northward occurs in species belonging to groups which have the greatest number of species, and those of largest size, in the colder latitudes; the increase in both cases being in the direction of the region evidently most favorable for the existence of the species.

"That the above cited variations in size, in coloration, and in the size of particular organs, have direct relation to the conditions of environment, is conclusively shown by the manner in which these variations occur. In many cases the extreme phases of differentiation presented by a wide-ranging species are so diverse that they were often formerly regarded as representing entirely distinct species, but subsequent material received from numerous intermediate localities has shown a complete and gradual intergradation between them; so that it has been found to be more in accordance with the facts to relegate many forms, formerly and, as then known, properly regarded as distinct species, to the rank of geographical races or sub-species. The passage from one extreme to the other, in any given case, is found to be as gradual as that in the climatic conditions of the two climatically very diverse regions under which these several phases reach their greatest specialization, and the majority of the species occurring together over a wide area tend to run into similar local phases of differentiation under similar conditions of environment."

These results are far too uniform and general in their effect upon widely distinct animals to be due to Natural Selection, in fact, I entirely agree with Mr. Allen that such uniformity of result here, and in the sponges, can only be explained by the action of physical surroundings directly working upon the organization and producing by such direct action the modifications or common variations above described.

If a uniform result follows upon the exposure of a given animal, and its congeneric forms, to the action of certain physical conditions, the modifications which result must be taken out of the category of those differences which may have been preserved by Natural Selection, the proper field for which lies in the preservation of those differences which arise through a tendency to variation, and are perpetuated and preserved simply because they are of advantage to some particular animal or race. To assume that only those species survive in these fields, the Mediterranean and others, whose organization fits them to become modified in a particular way, is perhaps a fact which may be verified some day by experiment, and in so far the law of the survival of the fittest probably obtains. What I mean to point out is, that within this limit the animals are modified so directly,

so generally and so uniformly in certain characteristics, by traceable physical causes, that I cannot imagine the intervention of any other secondary cause; there is no room for a struggle, or for selection, since the uniform action of a given temperature, depth, amount of sediment, sheltered locality, etc., have a corresponding uniformity in results, and are sufficient in themselves to account for the general modifications described.

The Mediterranean also affords us an admirable test of the Wagnerian hypothesis of an isolated locality, in which distinct races have arisen through the prevention of intercrossing with the parent races or species, and should give a triumphant example demonstrating the truth of that theory. That distinct varieties may arise in the same order on the same shore, according as they grow in shallow or deeper water, in clear or muddy water, and that these differ from each other in a manner which is similar to that in which the inhabitants of distinct regions differ from each other, is a fatal objection. Again, how could it have possibly happened that all three of the Mediterranean species, with their numerous varieties, arrived at the same general result, namely, greater fineness, density and elasticity of the skeletal fibres, through the mere prevention of intercrossing with the original coarse stock. Does it not seem at once evident, that if the coarse forms of the West were the progenitors, the first settlers of the latter would have produced at once in the new region all the usual variations, and that any general change in all of these would not be, could not be a question influenced by the prevention of crossing. On the same rule, the Chalinulæ in any of our estuaries, ought to differ from those in every other; but they do not, unless the temperature of the water, or some other physical change, brings it about. In applying Weissmann's modifications of Wagner's hypothesis to the explanation of any of the observed phenomena, I find myself equally at a loss. According to his ideas, a species has a variable and a constant period in its life history; if the isolated colonies are formed during the former period a new species results through "amixie," or non-intercourse with the parent species; if the colony is formed during the constant period no change can take place in this way.

Variability is generally correllative with the conditions of the habitat. Upon a hard bottom, or near shore, a sponge is apt to vary in a thousand ways to suit an equal number of changes due to the accident of its situation, here or there, wherever the larva may strike a suitable surface; if it is upon a sandy bottom, like the *Suberites compacta* Verr., it has a peculiar organization, which is remarkably dense and elastic, no base of attachment, and a flattened form to enable it to rest well on the bottom and be readily covered up in storms, rather than rolled about, and washed finally ashore; if it is an inhabitant of muddy bottoms then it has the anchoring threads fastening it in the mud, and the most invariable forms, so far as the species is concerned, necessarily due to the continued influence of the uniformity of its habitat. The shallow water forms, however, differ from the deep water forms; but in the genus Tethya, for example, there is the same rotund erect form, with a similar radiate arrangement of the skeleton, evidently due to the necessity of anchorage downwards as well as growth upwards. I cannot, consequently, with regard to the littoral genus Spongia, imagine any past or present condition under which it could become constant. Even when the conditions of the habitat are completely changed, the resulting modifications evidently take place immediately in the first inhabitors. Thus during an extended series of dredging in the

steamer of the United States Fish Commission, continued during several summers in Long Island and Vineyard Sounds, and south of Cape Cod, there was found upon hard bottom but one specimen of *Suberites compacta* Verr. This had formed a base of attachment, not to the top, but to the side of a stone, and did not rise in branches, as is usual with sponges growing habitually on hard bottoms, but lay flat, as if upon its natural bed of sand. In the same way, no change beyond what is necessary, takes place in the skeleton of Tethya[1] when it is found upon hard bottom, as is the case upon the English coast; a base of attachment is formed, but the skeleton preserves its peculiar radiate arrangement, and the typical shape is retained. How the law of "amixie" can be applied here, or to Mr. Allen's observations quoted previously, I cannot see; physical causes alone seem to be sufficient to account for the variations, and the law of heredity, that like produces like, to account for the persistence of a similar structure in forms, which, like the two last described, have migrated from the habitat where they probably acquired their peculiar organization.

Again, according to Weissmann's ideas, when a number of varieties enter a new and isolated territory, those varieties can only produce a new form varying from the parent species in the same way that they, as a whole, vary from the parent varieties as a whole. Thus if the wanderers include many aberrant forms having a large majority of individuals, the result of their crossing, when isolated together, would be a new aberrant form. It would not be at all probable that these species would enter a new locality with precisely the same, or even a similar assemblage of forms, and produce by "amixie" the same, or a similar result; but this is what must have been done in the present cases.

These remarks and criticisms are applied strictly to the characteristics which have been analyzed, and it is quite possible that when the anatomy, coloration, etc., come to be studied, that results confirmatory of the conclusions of Weissmann may be obtained, but the presumptions are now strong against this, especially in view of Mr. Allen's conclusions, which deal with the same class of external characteristics so fully studied by Weissmann among the insects.

I might also produce here, if it was essential to a clearer understanding of the subject, instances among the fresh water Polyzoa which are no less responsive to physical influences in certain important characteristics, but this is probably unnecessary. What I particularly wish to point out, and in so far, agree with Weissmann and several other evolutionists, is this, that there are certain characters in every species, which, though presenting many variations of a definite kind, do not arise through Natural Selection, and that naturalists who apply that law without carefully studying, not only what may be due to physical causes but to the tendencies and characteristics inherited from the ancestors of the group or species, are not likely to attain results which will add so much to the knowledge of philosophical zoology as if they had taken this side of the question into consideration.

The following observations were made upon the larvæ of several specimens preserved in alcohol, and though necessarily very imperfect, they are important, and seem to establish the following propositions.

[1] *Tethya gravida*, sp. n. Loc. Buzzard's Bay, is a new species found growing on mud in shallow water, and sustained by a base of loose fibres, which like a net catch and hold pebbles and sand sifted out of the mud, and, thus ballasted, the animal is held upright under all circumstances. See also Johnson's Encyclopedia, article Sponges, by A. Hyatt.

First, that the development of the genus Spongia resembles that of Chalina, which has been studied by the author, and that of the Halichondrida as expounded by Barrois, in all its principal characteristics, except the entire absence in the early stages of any signs of a skeleton, either in the form of threads or spicules.

Second, that, as far as known, the development is very similar to that of the Aplysine form, *Verongia rosea*, as studied by Barrois; but the basal collar and area, which play so prominent a part in the development of the genus Chalina[1] and the siliceous sponges, are also well developed in these larvæ, whereas they are less noticeable in Verongia.

Third, that the Spongiæ are by these characteristics of the larvæ distinctly separated from both the Aplysinæ and Chalininæ, and therefore rightfully occupy the intermediate place to which the structure of the full grown skeleton has hitherto caused them to be assigned by authors.

Fourth, that the sub-orders of the Keratosa, as far as known, are more easily distinguished in their early stages, in their larval than in their full grown forms, and that the assumptions drawn from the adult skeletons that the larger groups, such as the Aplysinæ, Spongiæ, Chalininæ, etc., run together through the structure of their adult skeletons, may perhaps be founded upon errors of observation, which will be corrected by more prolonged and thorough researches upon the differences in the mode of development of the similar structure exhibited by the fibres in these different groups.

This last position is not only supported by Barrois' observations on Verongia, showing that this genus of the Aplysinæ has a larva with the basal collar and central area much flattened; by my own observations on the Spongia, showing that the larvæ have a prominent basal collar and area, but no skeleton; and by my own unpublished camera drawings of the larvæ of two species of Chalina exhibiting the basal collar, area, and the skeletal spicules in the interior of the endoderm, with their bases showing below as bright points in the basal area; but also by the observations of Barrois and Carter, upon the development of Halisarca, which evidently does not belong to the Keratosa, since it is very distinct indeed from all the preceding.

In one alcoholic specimen of *Spongia agaricina*, sub-species *corlosia*, the egg at an early stage was found to consist, as in all other sponges, of a large cell, with nucleus and nucleolus. Each egg was surrounded by a clear transparent membrane, and nearly filled the middle of the ovarian capsule thus formed. As it increases in size the yolk becomes opaque and granular, obscuring the nucleus and nucleolus. Unfortunately the state of the specimens did not permit the mode of segmentation to be seen. Later stages of larval growth resembled those of *Spongia graminea*.

There was also only one alcoholic specimen of *Spongia graminea* in the Palmer collection containing larval forms. The earliest stage observed was considerably advanced. The process of segmentation was fully completed, and the division of the body of the larva into two regions had taken place. The interior appeared to be, as in the siliceous sponges at this period, entirely filled by minute granules, and the external membrane also, as in the siliceous sponges, to have become converted into long, cylindrical cells, but whether they were flagel-

[1] In this connection, I shall at present confine myself to mere statements, simply adding that I have ample evidence of the fact as stated, and have also been engaged for some time past in studying the sponges of the New England coast, and hope to give the results of my observations on Chalina and Isodictya in the next part of this Memoir.

lated or not, could not be seen in specimens so long preserved in liquor. On one pole of this larva there was a circular space of variable size loaded with dark pigment, and made up of apparently larger and rounder cells, at least that was their external or superficial aspect; they were not seen in section. This area became more definitely restricted and more symmetrical in outline in the next stage, and finally a distinct constriction separating it from the rest of the larva became visible. About the same time, or even previous to this, in some specimens a clear, round space appeared in the centre of this area, which I shall for convenience sake call the "basal" area, and the darker zone about it the basal collar. In the next stage a constriction or depressed line separates the basal area from the collar, which then stands out as a distinct raised ring, somewhat depressed along the central line by a slight sulcation in most specimens, but not in all. Sometimes the basal area in these alcoholic specimens is depressed considerably below the surface of the basal collar, but more frequently it is considerably raised above it, and this seems to be the normal condition at all stages.

The most curious folds take place in the larva from the contraction of the ectoderm, so that I was completely deceived into the belief that they represented the earliest stage of the development of the complicated fibrous skeleton in the first specimen I saw, which happened to be one with very symmetrical folds, or rather channels, on the surface. The larva at this stage is still surrounded by the thin hyaline membrane previously noticed, and when three or more are close together this capsular membrane becomes a prominent feature. The cells composing it are of large size, in diameter about equal to the length of the ectodermal cells.

After the appearance of the pigment at the basal end, sometimes before the collar is formed, and in some cases subsequently, a similar gathering of pigment is observable at the opposite pole. Then probably at an equally variable succeeding period, the cells at this extremity take on the rounded aspect externally of those of the basal collar, and the ectoderm becomes decisively thinner at this place. I saw this in only one specimen, but it happened to be a remarkably fine and unusually transparent form, showing the fully developed basal collar and basal area. There was no aperture visible at this point, which might be called the cloacal pole, though the central cells of the ectoderm were distinctly visible.

It will be observed that these cursory observations are strongly confirmatory of those made by Barrois upon his *Verongia rosea*, but not of his *Gummineа ? mimosa*, the young of which resemble more closely those of true Halisarca, as figured by Carter and observed by Barrois and Carter, and have a significant resemblance to the young of the Calcispongiæ.

The observations of Barrois upon *Verongia rosea* show about the same stages of development as those of Spongia described in this paper, with the exception of his fig. 39, which, as one of the last of the simple stages of segmentation, was not observed by me. My observations have led me to regard the skeleton of the Keratosa as the product primarily of the ectoderm, and those of Barrois previously quoted sustain this view. The stages observed by me in *Spongia graminea* and *corlosia* correspond to Barrois' figs. 23, 27, 28 of the siliceous sponge on his Pl. 15, and his figure on Pl. 14 of *Verongia rosea*, corresponds to fig. 26 of Pl. 15. It is subsequently to this that the basal collar and area are formed, and that the larva of Spongia assumes characteristics similar to those of the larva of Chalinula, and some other siliceous sponges of the true Halichondrida observed by me at Eastport, Maine; but in none of the species of the siliceous sponges examined did I wit-

ness the determination of the pigment particles to the opposite or cloacal pole, as described by Barrois. This coloration has been seen by Barrois, however, in his *Verongia rosea*, and the area is figured as a bare space, Pl. 15, fig. 41, and has been observed by Carter, Barrois and myself, in several different species of the true siliceous sponges and Chalinulæ, as a bare projecting knob at the cloacal pole, which invariably appears to be imperforate.

DESCRIPTIONS OF GENERA AND SPECIES.

Spongia Auct.

Euspongia Bronn. *Caccospongia* Schmidt.

The skeleton is composed of solid elastic fibres. The structure is irregularly radiatory. The primary fibres, those having their origin in the external integument, are usually though not invariably more or less radiatory, but the secondary, or connecting fibres, are excessively irregular, and generally very closely intertwined. The primary fibres are particularly noticeable on the inner side of the walls of the excurrent openings. A very regular structure of the skeleton is found more or less in the walls of the larger cloacal canals and in the young of nearly all species, and in the adults of some undoubted specimens of Spongia, but, as a rule, there is no very definite arrangement, like that in Spongelia. The specimens, however, in which a radiatory arrangement of the primary fibres cannot be detected, are exceptional among the Florida sponges, though perhaps not so common as among the Mediterranean forms. The skeleton exhibits a very rough surface. This is due to the development of large projecting masses of the secondary fibres, which are separated by horizontal channels of greater or less depth. The primary fibres protrude above the surface of the cushions or ridges thus formed, carrying with them more or less of the secondary fibres, and forming a series of sub-dermal or superficial tufts, giving the skeleton a peculiarly hirsute aspect. In some sponges these, like the cushions or ridges, are absent, though I have failed to find any of this genus in which both have been wanting; *i. e.*, a specimen with a perfectly smooth, even surface.

This structure of the surface, when it is covered, as in the living state, by the external membrane, gives a very peculiar aspect to the subdermal region. This appears to be undermined with innumerable holes and channels, which open below into the water system, and externally by means of pores through the dermal membrane. These pores are very numerous, quite permanent in their position, and though irregularly scattered over the sides of the mass, often remain open even in dried specimens. The cloacal canals are few in number but exceedingly large, and the interstitial canals very numerous and not comparatively very small. The large excurrent apertures are irregularly scattered about, but almost always on the upper side of the colony.

The dermal membrane in a living condition is of a dark brown or very dark purple or black color. The external layer is usually more or less filled with whatever sediment may be prevalent in the water, and, especially in the West Indies, with the siliceous spicules of other sponges. A sort of selection also appears to be exercised in favor of the simplest and finest forms of spiculæ, which I presume are more abundant in the surrounding water. These, together with minute fragments of stone, pass into the substance of the primary fibres, which are rarely free from such impurities. The secondary fibres, owing to their mode of deposition within the ectoderm are, however, always clean.

In describing the species of this genus I have made comparisons between three principal Mediterranean, and three of the American commercial sponges, in order to show the very evident relationship of these forms. Schmidt describes five Mediterranean species in all, and may be right; but so far as I can understand his descriptions, with the aid of a fine collection of specimens purchased by Prof. Baird for the National Museum, from Mr. Isaacs of New York, I cannot make more than three out of the ordinary commercial varieties, which were fully represented and appeared to include the entire range of his five species. Von Eckhel's work upon the "Badeschwämme," although a purely commercial treatise, has the same view of the affinities of the sponges, based upon the observations of the fishermen and dealers, and the distribution of the species; the latter is quite remarkable. Only one species, the *Spongia officinalis* Linn., *Adriatica* Schm., is found on the eastern shore of the Adriatic and coast of Greece, from Trieste to the Bay of Nauplia. From Nauplia and the island of Candia to Eritra, on the coast of Asia Minor, two occur, *Spongia officinalis* and *Spongia agaricina* Pall., *Zimocca* Schm. From Eritra, opposite the island of Chios, to Tripoli, all three, *Spongia officinalis*, *agaricina* and *equina*, are fished, except at the island of Cyprus, where the Zimocca sponge does not live. From Tripoli to Tunis two only occur, *Spongia officinalis* and *equina*, and from thence to Ceuta at the Straits of Gibraltar, a very peculiar, dark colored and coarse variety of the *Spongia equina* is obtained, called the Gerbis sponge.

This distribution indicates the naturalness of the three species, and shows also that the dealers have to do with a vast variety of forms. They can, however, pick out the three species and their varieties without hesitation, and I was amused and interested at finding that the method pursued was precisely similar to that which I had been obliged to adopt in distinguishing empirically the various sub-species and species of Spongia. They are led mainly by the general aspect of the surface. This has a distinct appearance in every species, and though much altered by the greater or less development of superficial tufts, is much more constant than any other character. This is due to the fact that the surface takes its aspect largely from the number, distribution and size of the pores, cloacal orifices, superficial canals and primary fibres. These characteristics, of course, are directly correllated with all that is important in the internal anatomy of the animal, and should therefore be more constant than the length, form or composition of the tufts of fibres, or the shape of the whole, which are capable of great modification, according to the locality in which the specimen may be found. The forms of *Spongia officinalis* may vary from cup-shaped to fistular, and to irregular or lump-like. The latter are usually coarser and looser in texture, the superficial tufts are longer and more numerous, and they approximate more closely to the coarser varieties of sub-species *tubulifera* of the Carribean Sea in the external aspect of the surface and the apertion of the interior, than the finer varieties.

The texture of the poorest variety of the Mediterranean sponges is, however, always better for domestic purposes than the best of the corresponding American varieties, being firmer and more elastic; and it is also to be remarked, that the last never have the cup-shape, which is so common in the sub-species *Mediterranea*, and that the fistular form takes its place. The forms of *Spongia agaricina*, sub-species *Zimocca*, vary from saucer-shaped to irregular lump-like growths. As in the *Spongia officinalis*, it may be shown that these aberrant forms are quite similar to the aberrant or formless varieties of the sub-species *punctata* of Florida, as regards the aspect of the surface; but these also are nevertheless much

finer than the finest varieties of the latter. Here, again, the platter or saucer-shape, which is a modification of the cup-shape, is absent. *Spongia equina* exhibits similar degrees of variation in the texture of the surface and the form. There are no proper cup-shaped specimens among the American varieties of sub-species *gossypina*, but in place of these the fistular form. These occur generally associated in clumps, more or less densely filled up into heads, and solid, but sometimes the tubes are almost isolated, as in the specimen figured, Pl. XVI, fig. 7. The younger specimens of this species have a very loose and open texture, due to the approximation and large size of the openings, and to a less degree this is also to be remarked in the Gerbis sponge. The former approximate in aspect to the coarser qualities of the American species, and so also does the latter, which has very nearly the same color and aspect as the dark colored Key West specimens, but is not so coarse or dark. It seems, then, that there are three sub-species of commercial value in the Mediterranean, and although there are more than three in the list of the American forms which follows, there are really only three, or at most four, sub-species, which find their way into the New York and European markets. The coarsest varieties of the European sponges are finer, firmer, and more elastic than the finest of the corresponding American sub-species. This is directly traceable to the larger amount of foreign matter included in the primary threads, the looser mesh of the tissue; the fibres are also comparatively coarser and the large cloacal channels more numerous throughout the mass. Nevertheless we can select specimens which it would be difficult to distinguish, such as the fragment, Pl. XVI, fig. 1, taken out of the side of a large Florida or Nassau sponge, of such exceptional fineness that only the very loose texture, form, dark color, and collection in which it was found, enabled me to separate it as an undoubted Carribean form. Compare this with fig. 8, and also compare fig. 16, a piece from the side of an old specimen of a Carribean form of sub-species *tubulifera* with the under side of fig. 18, a true cup sponge from the Adriatic of rather coarse quality. There is precisely the same sort of relationship here as I have observed between the different qualities of sponges existing in the same seas. Thus the different varieties of sub-species *gossypina* differ in an exactly similar way from each other, and from the third form, sub-species *cerebriformis*. They differ in texture, in surface, and also in habitat, the finer kinds, as stated previously, being found in the deeper water, equally removed from excessive heat and excessive sediment. These three sub-species run together by means of specimens of the coarser varieties, which cannot be distinguished from each other with any certainty, in the same manner as the corresponding sub-species in the Mediterranean and Carribean Seas were connected, through the coarser, and not by the aid of the finer varieties. It is evident, however, that besides the general differences noted on previous pages, that the cup-shaped form is not found in the American sub-species, whereas it is the prevalent form of the Mediterranean sub-species. A cursory examination of a large collection will, however, satisfy any one that the shape does not necessarily correllate with a finer or a coarser skeleton, but probably with a more or less extended base of attachment and local peculiarities, such as currents, and the kind of bottom, etc., which have not been investigated in this connection.

In order to obviate the technical difficulties attending the labelling of specimens according to the trinomial system, it has been suggested to me that the sub-species name should be inclosed in brackets, thus, *Spongia officinalis* [*tubulifera* D. et M.] Linn., var. *rotunda*. To this, however, though it would as completely represent the true affinities of the sponges

as is perhaps possible, the objection might be made that it is altogether too cumbersome for the purpose of labelling collections for exhibition in Museums, and might lead to some confusion in the use of the names here proposed. I therefore append a list below, made out according to the usual method, every sufficiently distinct form being labelled as a different species, so that one may have a choice.

Spongia officinalis Linn. = { *Spongia Adriatica* Schm. / " *Quarnerensis* Schm. } = sub-species *Mediterranea*.

" *mollissima* Schm. = variety *mollissima* (Levant sponge and Turkey Cup).
" *tubulifera* Duch. et Mich. = species *tubulifera*.
" *discus* Hyatt.
" *lignea* Hyatt.
" *graminea* Hyatt.
" *equina* Schm.
" *gossypina* Duch. et Mich. = sub-species *gossypina*.
" *meandriniformis* Duch. et Mich. = sub-species *meandriniformis*.
" *cerebriformis* Duch. et Mich. = sub-species *cerebriformis*.
" *agaricina* Pall. = *Spongia Zimocca* Schm. = sub-species *Zimocca*.
" *dura* Hyatt = sub-species *dura*.
" *punctata* = sub-species *punctata*.
" *corlosia* Duch. et Mich. = sub-species *corlosia*.
" *vermiculata* Duch. et Mich.
" *Cookii* Hyatt = sub-species *Cookii*.
" *molliata* Hyatt = sub-species *molliata*.
" *lapidescens* Duch. et Mich.
" *dentata* Hyatt = sub-species *dentata*.
" *Mauritiana* Hyatt = sub-species *Mauritiana*.
" *tectoria* Hyatt = sub-species *tectoria*.

I have found myself entirely at a loss in the attempt to use the microscopical structure and arrangement, or size of the fibres in the descriptions of the species and varieties. The number of illustrations necessary in order to show the variations in one single colony, and in any one of the better represented species would have filled several plates. The expense and doubtful utility of attempting to delineate fully, structures so evidently subject to local modifications, and the necessity of a strict economy in the Society's publications, caused the abandonment of all figures of the skeletal structure in order to secure a more complete representation of the constant characteristics of the external surface.

The series of slides, however, prepared by Mr. Crosby, Assistant in the Society's Museum, and myself, represent many varieties, and from these, and others of a more temporary character, have been taken the remarks with regard to the microscopical structure of the skeletons which accompany the specific descriptions.

Spongia officinalis Linn.

Spongia officinalis Esper. Pflanzenthiere, vol. 2, pl. 15.

Sub-species **Mediterranea.**

Variety *Adriatica.*

Spongia Adriatica Schm., Spong. d. Adriatish. Meeres, p. 20.

Spongia Quarnerensis Schm., ibid.

This variety, Pl. XVI, figs. 18, 19, has a somewhat coarser texture than the true Levant and Syrian varieties, which have a denser mesh and finer fibres. The forms vary from those which are typically cup-shaped to a flattened Zimocca-like form, or to a mere aggregate of fistular branches, which are generally more or less closely associated. The typical or cup-shaped form is often open on the side, or even varies to an almost solid form, with the excurrent orifice gathered into a hollow at the top. The fibre is fine and close and soft to the touch, the tufts of the surface very small. It is prevalent in the Adriatic Sea, according to Von Eckhel, and becomes identical farther south with the fine textured typical Turkey Cup sponge, and the finest of all sponges, the Levant Toilet sponge, both of which are included under the name of *mollissima.*

Variety *mollissima.*

Spongia mollisima Schm., Op. cit., p. 23.

This variety, Pl. XVI, fig. 21, may be either cup-shaped or more or less solid, differing from the other varieties simply in the fineness and extreme density of the closely woven fibres. It was probably this which led Schmidt to separate it as a distinct form, but there are intermediate varieties, which show that this is an incorrect conclusion.

Variety *tubuliformis* (Pl. XVI, fig. 20) may be either cup-shaped, or more or less of a solid form, either lobed or fistular, but in all specimens the superficial bundles of fibres are very long and numerous, giving the edges of excurrent apertures and the whole surface a very hirsute aspect.

Variety *zimocciformis.* It may be well to describe another variety in which the peculiar aspect of the upper surface and the typical saucer-shaped form of the *Spongia agaricina*, sub-species *Zimocca*, is so closely imitated that some specimens might be mistaken for that species, but in others the whole upper surface becomes flattened and table-like, and very dense and smooth.

The more solid specimens of variety *tubuliformis*, especially those of irregular shapes, approximate in the young to the most open and least useful varieties of the Florida sponge, sub-species *tubulifera.* I cannot see, since Dr. Ehler's paper, why it is either necessary or proper to hold to Schmidt's name of *Spongia Adriatica.* It was correct, so long as the Esperian sponge was unknown, to drop the old name, which by too general application had become useless, but now that we can return to this and give it an exact meaning, it becomes essential to retain it.

Sub-species **tubulifera.**

Spongia tubulifera Lam., Anim. sans Vert., vol. ii, p. 363, 2d Ed.

Spongia tubulifera Duch. et Mich., Naturk. Verhand. Hollandische Maatsch. Wetensch. Haarlem, 2 Verz. 21, 2, p. 34, pl. 4. 1864.

If any reader wishes to compare this variety as a whole with the sub-species *Mediterranea*, he will do well to contrast fig. 15 with fig. 21, fig. 13 with fig. 19, fig. 10 with fig. 20, and especially fig. 16 with fig. 18. In every case these figures occur on Pl. XVI, and the

first mentioned refers to a specimen of sub-species *tubulifera*, and the second to the corresponding quality of sub-species *Mediterranea*. It will be observed that the divergence is greatest both in form and texture in the finest quality, figs. 15 and 21, and that the approximation of the varieties occurs in the lower or less regular and coarser forms, such as figs. 10 and 20, and still more closely in figs. 16 and 18. The first of these last is a fragment of an old specimen of *tubulifera*, and the last is the surface of a very coarse specimen of *Mediterranea*.

There are several prominent variations in the mode of arrangement of the fibres when examined by the microscope, of which the following are perhaps the most remarkable.

1. The primary fibres single, continuous, projecting, stout. From the terminations of these hang festoons of secondary fibres, forming the superficial, interstitial skeleton.

2. The primary fibres either single or treble, and more or less continuous below as a sort of closely woven fascicle.

3. The primary fibres project in a fascicle of two, three or more, but are deflected laterally below, and are not continuous in the body of the skeleton as vertical fibres. Their presence is indicated below by a denser mesh of fibres surrounding a continuous, or nearly continuous, and somewhat tortuous track of debris. The mesh of connecting or secondary fibres is proportionally about equal in length and breadth in all the specimens examined.

This sub-species has, as compared with other American sub-species, a skeleton composed of remarkably fine fibres, which bleach out to a whitish brown color. The surface is covered with fine tufts of primary fibres which are, however, very pliable. The surface is generally quite free from cushions and ridges, and the channels between these when they do occur, are neither very deep nor long. The result of these characteristics is a form with a smoother surface and a denser looking skeleton than usual, pierced on the sides by numerous small apertures very regularly distributed, and at the top by one or more large cloacal oscules. The form is generally dome-like, and is never, so far as I know, cup-shaped, though it may become exceedingly irregular, fistular, or even dendritic.

The older specimens show a decided tendency to increase by the prolongation of the parts immediately around the apertures. Thus the main body of the sponge becomes projected into numerous smaller conical or head-shaped masses, like the young of variety *rotunda*, and crested masses like those of variety *disciformis*. At an advanced age the fibre becomes very brittle, and unfit for domestic purposes.

Dr. Palmer reports that this species is found generally associated in considerable numbers, not often growing either upon other sponges or upon corals, but generally upon hard bottom. Color while living is black, and the largest seen was about eight inches high by about twenty in circumference.

Loc., Key West, Nassau. Habitat, hard bottom or reef in six feet of water.

Variety *pertusa* (Pl. xvi, fig. 11–11*a*). The colony in this variety is composed of several fistular elevated orifices of the ordinary density of texture, but united by a depressed portion of extremely porous structure. The secondary tufts or pencils are of extraordinary length upon the flattened central portions. Under this head is included a number of forms in which the fistular orifices are numerous. These being more closely approximated than in other sub-varieties, this intermediate depressed portion disappears, and the sponge acquires the characteristics of the next variety.

Variety *mollis* (Pl. XVI, fig. 12). The skeleton is perforated by many large canals opening through the upper surface, the tissue between is also very porous, and the aspect is that of a number of fistular sponges united into a more or less complete head.

Loc., Nassau, in Soc. Coll., and Havana, Island of Noronha, Province of Pernambuco, in Coll. Mus. Comp. Zoology.

Variety *prava* (Pl. XVI, fig. 17). This variety is similar to the preceding in most of its characteristics, but differs in the entire suppression of the projecting apertures and the smoothness of the surface, broken only by numerous superficial canals.

Variety *disciformis*. This is, properly speaking, perhaps one of the typical forms, since the texture is throughout like the best quality of commercial sponges. It may have only one or two large apertures, or it may have several, but they are mostly arranged in a row along the crest of a flattened or helmet-shaped sponge. Its resemblance to *discus* is limited to this characteristic. It may possibly be identical with *Spongia musicalis* Duch. et Mich.; the surface appears to agree with that of their drawing. Other specimens, however, which might be best referred to this variety, have not only the helmet shape, but are distinguished by the presence near the oscules of fringe-like tufts. Others, again, have the prominent tufts of primary fibres over the whole surface, with the form of *rotunda*.

Variety *rotunda* (Pl. XV, fig. 1; Pl. XVI, fig. 15). In the young this variety may have a conical form, with only one fistular orifice, but generally, either at an early period or later in life, there are several orifices. The rotundity of the form becomes more marked in proportion to the number of these. There are also all grades of full grown forms: those which are almost conical, with only two or three orifices, like the young just described; those in which the top is almost round; and those with series of sunken apertures dividing the top into radiating ridges, with more or less deeply marked depressions between. The apertures in the round solid heads are not only apt to be more numerous, but also smaller than in any of the other forms.

Variety *aperta*. This is precisely similar to the rounded and firmest specimens of the preceding, and like that may have apertures which are either small and numerous, or larger and more sparsely distributed. The interior, however, is cut through by huge channels, which render its solid aspect a mere sham. These channels, or open galleries, penetrate frequently in every direction, anastomosing with each other, and finally opening somewhere upon the sides. They are not to be confounded with the apertures, since they are mere galleries through the substance of the sponge, and are lined by the external membrane.

Variety *corlosiformis* (Pl. XVI, fig. 14). This name is given in allusion to the form, which has the flattened aspect above, and general outline of variety *corlosia*, but otherwise it does not resemble that species. The colony is in some specimens cavernous, as in the preceding variety; in others it is solid, the apertures, however, are generally larger, as in the more conical specimens of variety *rotunda*.

Variety *duplex*. This variety is caused by the growth of several long, thick, solid branches, making a peculiar dendritic form. The orifices are large, and situated on one side. The texture of the single specimen examined was a little coarser and darker than is usual in this sub-species.

Loc., Havana, in Coll. Mus. Comp. Zoology.

Variety *exotica* (Pl. XVI, fig. 13). Differs from the preceding merely in its long fistular orifices closely approximated, or nearly completely separated.

Loc., Nassau, in Soc. Coll.

Variety *solida* (Pl. XVI, fig. 10). This is part of a larger specimen preserved in Ward's Museum, Rochester, N. Y. The branches are solid, as in variety *duplex*, and also have the cloacal apertures on the sides, but are palmate or flattened in form instead of rounded. The surface is rather smoother than in most varieties, except *rotunda*.

Spongia discus D. et M.

Spongia discus Duch. et Mich., Op. cit., p. 37.

The specimen figured (Pl. XV, fig. 3) so closely corresponds with the description given by Duchaissing and Michellotti, especially with regard to the surface, that I have thought it best to retain their name. If these authors had not given it a distinct name I should have doubtfully referred it to sub-species *tubulifera* as a variety, though I know of no variety which presents so marked a departure from the type of its species in the aspect of the surface. The comparison made by these authors between the surface of specimens dried with the epidermis remaining and the channeled surface of worm-eaten wood, is remarkably good, and it can be separated from sub-species *tubulifera* by the spinous look of the tufts of primary fibres, and the greater stiffness and dark purplish color of the skeleton.

Loc., Nassau, in Soc. Coll.

Variety *anomala*. This curious form appears to agree in all respects only with *discus*, of which species it is certainly wisest to regard it as a variety. The colony is composed of an irregular assemblage of fistulose sponge masses, extending in an irregular manner over the corallum to which it is attached. The whole is about six inches long, three inches in height at the deepest part, and about three inches thick. The central portion is made up of a line of four or five large apertures elevated upon a sort of crest which appears to be composed of a number of fistulose masses formerly separate, but now welded together. On the sides, and more or less intimately united with these, are two fistulose branches. The color is purplish, as it is also in the dried specimen of the typical *Spongia discus* just described, and the locality is the same. The surface has not that worm eaten aspect which distinguishes the surface of the typical form, but it approximates to that condition. That is to say, it has larger secondary tufts of fibres than sub-species *tubulifera*, and otherwise resembles *Spongia discus* in the generally rough irregular aspect of the surface.

Loc., Nassau, in Soc. Coll.; Havana, in Coll. Mus. Comp. Zoology, and Bermuda, in Coll. Acad. Nat. Sciences of Philadelphia.

Notwithstanding these very distinct characteristics, I describe *Spongia discus* as a distinct species with considerable doubt, feeling that it may, with more evidence, prove to be merely a variety of *tubulifera*. This doubt has been much strengthened by the receipt of another Bermuda form, a fragment of which was recently forwarded me by Mr. Goode. This has an aspect more closely like *tubulifera* than any of the above, though the skeleton is still very dark colored and very coarse.

Variety *Nicholsoni*. This variety is very similar in the aspect of the surface to the typical form, but has a coarser fibre and stiffer skeleton when dried. The color of the skeleton varies considerably from a dark purplish brown to a very light brown. The aspect of this variety approximates remotely to *Spongia graminea*, and leads the observer to think

that they can be joined; this, however, is not the case, and the resemblance disappears upon close comparison.

Loc., New South Wales, near Sydney, in Acad. Nat. Sciences, Philadelphia and in Soc. Coll.

Variety *Auklinensis*. This remarkable variety spreads out into flat masses with projecting orifices, more or less fistulose, and branches. The whole surface is exceedingly hairy, owing to the number and length of the bundles of projecting primary fibres. These are, however, similar to the more scattered ones of variety *Nicholsoni*, and the surface otherwise resembles that species.

Variety *ligneaformis*. This variety is so named because the skeleton is considerably denser than in the two preceding varieties, the tufts less spinous and smaller, and all the apertures smaller and more numerous. The fibres of the skeleton are also finer and more densely woven together.

Loc., Florida? in Coll. Acad. Nat. Sciences of Philadelphia.

Spongia lignea Hyatt.

This species has the densest skeleton with the closest texture of any known sponge. The fibres are quite fine, and the whole so hard that it cannot be compressed by the fingers. The largest specimen I have seen exists in the collection of the Academy of Natural Sciences, Philadelphia. This is very much cut up in the interior by large channels, but feels as if made of cork, or wood. Unfortunately, it is much beach worn, so that the original surface could not be studied.

Loc., New South Wales, near Sydney, in Coll. Acad. Nat. Sciences of Philadelphia.

The following varieties are closely allied to the preceding, and are probably the same, but I have not the material to determine this question with certainty.

Variety *levis*. One specimen from the Collection of Yale College, United States Exploring Expedition, locality Pacific, exhibits a surface almost devoid of the projecting tufts, owing in some measure probably to attrition on the beach. Where the surface has been left entire in the hollows, the tufts are present, but not abundantly developed. The texture is excessively dense, and the surface reminds one strongly of that of sub-species *tubulifera*. This is owing to the immense number and small size of the incurrent, and the paucity of the excurrent apertures.

Variety *arborescens*. There is one of the branching specimens exhibiting many of the superficial and textural characteristics of this species, which belongs to the Collection of Yale College, locality Pearl Island, Panama Bay. It seems closely allied to variety "*levis*" in every respect except the branching form.

Variety *crassa*. A specimen from Bermuda, in the Peabody Academy Collection, has been referred also with some doubt to this species. It is very similar in most respects, but the fibres are quite dark colored, and the secondary tufts stiff and rather short; otherwise the surface and general aspect agree with those of variety *levis*.

A specimen from Mauritius, in the Collection of the Museum of Comparative Zoology, may possibly belong to this species. The texture is, however, quite similar to that of sub-species *Cookii*, "var. *vermiculatiformis*," while the surface is perhaps more like that of the typical variety of this species. There are here and there large oscules, four or five millimetres in diameter, with numerous smaller ones irregularly scattered between them. The mesh is rounded, or cellular in aspect, and quite spongelia-like on the surface. The

surface is covered in part by fringes having the branching form of those figured by Duchaissing and Michelloti, as characteristic of this species. There are also two other specimens which exhibit a similar surface from the same locality, one of them a young colony with a smoother surface and somewhat softer than is usual in large specimens.

Variety *Hawaiianensis*. One specimen from Hawaii, West Coast, exhibits the peculiar surface of this species, and its characteristic skeletal structure, but is much coarser than any other form.

Spongia graminea Hyatt.

This (Pl. xv, fig. 2) is one of the "Grass sponges" of commerce, and is perhaps one of the least variable of all the species. The general description given by Duchaissing and Michelloti for *Spongia utilis*, might at first sight appear to apply to this sponge, as it might indeed to almost any of the group; but there is one remark which enables me to determine the question of identity. "Des oscules superficiels très-nombreux et ayant à peine une ligne se prèsentent sur tous les points de la surface supérieure, mais cependant de préférence sur les parties les plus saillantes." This last word is decisive, since in this sponge the situation of the apertures in the depressions between the lobes or ridges is especially constant and characteristic.

The general texture is coarser than in variety *tubulifera*, and the interior is exceedingly open, owing to the large size and central situation of the efferent canals. The form is that of a truncated cone, fluted by deep furrows on the sides, and either infundibuliform or flat on the truncated surface. The large excurrent orifices are all upon this surface, or in the depression which takes its place. The smaller apertures are situated on the sides, invariably in the depressions between the ridges. The persistency of the form and of the lateral ridges and the situation of the different kinds of orifices, are by far the most characteristic features of this species. Notwithstanding these facts, and though I am obliged to describe this, and some other forms, as distinct species, I have great doubts of the truth of the assumption. It rests upon the evidence of many specimens, but they are all from one locality. It is very likely that this and *Spongia discus*, and perhaps even *Spongia lignea*, will be found to have intermediate forms. I have also recognized indications of an approximation to sub-species *corlosia*, but the material at my command is not abundant enough to settle these questions satisfactorily.

This species has very singular fibres in the skeleton. The primary and secondary are of nearly equal size and very light colored in a cured skeleton. The mesh is irregular in shape. Even the secondary fibres were not free from debris in the specimen examined, and in some parts of the same it was impossible on account of the absence of the usual core of debris to pick out the vertical fibres.

It is reported to be very abundant by Dr. Palmer, growing on reefs, and generally associated in considerable numbers. They may grow on smooth bottoms, or attached to corals or to other sponges; a somewhat remarkable peculiarity. The color is black in the living. Those in our collection were found in three feet of water. There is one about seven inches in height to about five and a half inches in diameter, but they are said to grow to twice that size in deeper waters.

Locality, Key West. Habitat, reef three feet and deeper. Soc. Coll.

Spongia equina Schm.

Spongia equina Schm., Spongien d. Adr. Meeres. p. 23, pl. 2.

This species more closely resembles our ordinary forms of West Indian sponges than any other European species. The form may vary considerably, but is remarkably and constantly solid in the specimens offered for sale, and semi-globular in form. The color of the fibre externally, and the tufted surface, shows the same close approximation to the corresponding American forms of the sub-species *gossypina*, as was noticed in the preceding species. It has a similar openness, being a net work of large excurrent orifices closely approximated and fringed with prominent bundles of superficial fibres. These characteristics are also particularly marked in the young, especially in those varieties which grow laterally into flattened forms. Compare for purposes of identification, Fig. 1 with Fig. 8, Pl. XVI. The first is a flat variety of a Mediterranean sponge, and the latter a fragment cut out of the side of an aged specimen of sub-species *gossypina*, of remarkably fine texture. There is here evidently a fact of the same nature as that previously noticed in the comparison of the Mediterranean sub-species of *Spongia officinalis* with the American sub-species; the approximation in each case is made by means of the inferior qualities, the aberrant forms. Or if the comparisons are made between the stage of growth of any single colony of the American sub-species and the coarser kinds of the Mediterranean sub-species, the closest approximation is obtained by comparing the old age of the American sponge with the full grown of the European. This is due to the fact that the American sub-species loses in old age the tufts, or prominent pencils of primary fibres which are so numerous in the adult colonies.

The Gherbis sponge (Pl. XVI. fig. 9), a "sort" which occurs between Tunis and Ceuta, has a darker color and coarser fibre than the more eastern varieties. This color and the aspect of the surface make them very similar to the American, especially the Key West forms of sub-species *gossypina*, and this resemblance is rendered even more exact by the structure of the superficial bundles of fibres, which are much broader and more loosely connected than is usual in the Mediterranean sponges, giving the surface of some specimens a precisely similar aspect.

In the shops this sponge frequently goes by the name of the Venetian Bath-sponge, though in Europe the only name popularly employed seems to be that of Horse Sponge.

Sub-species **gossypina.**

The fibres are generally, but not invariably, somewhat coarser than those of *tubulifera*.

1. Primary fibres single, widely separated, continuous below, projecting above, stouter than those of *tubulifera*. The meshes of the connecting fibre are also very broad, sometimes extending without interruption from one primary fibre to another.

2. Primary fibres in groups, but not fasciculated. They converge towards the surface, and project in several apparently single points. Meshes of the connecting fibre narrow and long, or of equal dimensions, but never so large as in No. 1.

3. One section of sub-species *meandrina* shows the primary fibres absolutely free of debris, rising in single points above the surface, but not continuous; they being soon lost below the surface in the small, dense net work.

4. Another specimen of the same sub-species shows the primary fibres continuous below, coarse, loaded with debris, the connective tissue with a looser mesh and much finer fibres than No. 3.

Sub-species *cerebriformis* was found to have fibres of even a grade coarser than those of variety *typica* of *Spongia agaricina*, sub-species *dura*, and quite as dark colored.

1. In some cases excessively loaded with debris, which sometimes was not confined to the axes of the primary fibres, but hung in pieces from the exterior, apparently partly uncovered. Primary fibres are usually arranged in fascicles and bundles.

2. Primary fibres single, widely separated, connecting fibres placed nearly at right angles to these, but with a small mesh. The primary fibres always, and sometimes even the connecting fibres, loaded with debris. This last fact becomes of great importance in view of its exceeding rarity, and since it shows that under some circumstances even the generic characteristics of this part of the skeleton are subject to individual variation.

3. Same as above, but without debris in the connecting fibres.

4. Same as above; but the fibres are light colored, and in every essential point like those of *gossypina*.

5. Fibres of *obscura* closely resemble those of the coarser kinds of variety *gossypina*, but the connecting fibres are larger in proportion to the primaries.

Spongia gossypina Duch. et Mich., Naturk. Verhand. Hall. Maatsch. Wetensch., Haarlem, 1864, 21–2, p. 32, pl. 3, fig. 3.

The typical variety of this species, usually called the Wool sponge, varies greatly in form. All of these forms, however, are characterized by a peculiar surface. The skeleton rises into large tufts over the entire surface, the larger oscula occupying the depressions between. Sometimes these are very numerous, the whole interior being very cavernous, and sometimes the structure is much denser, with fewer large openings and many smaller ones scattered between the tufts. Occasionally, the depressions are filled up on parts of the sponge, and a surface is presented having no large tufts, but only the small secondary pointed bundles of fibres, which are especially characteristic of this variety.

The result of this structure is to leave great hollows, or rather a network of deep tunnels under the derm, which are apparent only after the drying of the specimens, when they become exposed by the universal contraction and cracking of the skin. The color when living is said by Dr. Palmer to be a shining black.

Loc., Biscayne Bay, Key West and Nassau, in Soc. Coll. Habitat, from three to sixteen feet, and deeper, the limits not being ascertained. The largest seen was about nine inches high by thirty inches broad.

Variety *dendritica*. This I have founded simply upon one form, Pl. xv, fig. 6, which is fistulose and branching, each branch having one large aperture at the tip. The surface is ornamented with the usual tufts of fibres and long ridges, as in *Spongia graminea*. There are others of similar texture in which the association is fistular, but the form is solid and not branching, though quite long.

Loc., Nassau, in Soc. Coll.

Variety *porosa*. These are also compound fistulose forms, but the tubes are widely scattered, short and wide-mouthed, giving the whole a flattened table-like aspect, and the skeleton between is very scantily built. One form of this variety has a denser skeleton

between the tubes, and the fistular aspect is consequently almost lost, Pl. XVI, fig. 5. This leads into the following form which may be styled normal or typical.

Loc., Nassau, in Soc. Coll.

Variety *alba*. The name alludes to the whiteness of the fibres. The preceding form merely increases in size with its widely separated fistular tubes (Pl. XV, fig 4), and with a dense skeleton between, rounding upon the top until quite a tall, stout head is built up, which in its most perfect form is quite symmetrical, but this leads into fistulose forms, such as the figure (Pl. XVI, fig. 7). The primary tufts are very large in this variety, as in variety *isolata*. With this I should also associate the large, flat-topped, large apertured and loose textured specimens, which have small bases of attachment and rounded swelling sides. There are also some very interesting forms which lead from these into the next. They have the same surface and texture, but instead of many, have only one large aperture in the centre of the elongated circular head.

Loc., Biscayne Bay, Nassau, in Soc. Coll.

Variety *solitaria*. This (Pl. XVI, fig. 3) has only one large aperture, with a very much elongated, and altogether fistulose, aspect. The difference consists in the absence of the fibrous tufts over considerable spaces, giving the surface thus changed a peculiarly solid aspect. This leads into sub-species *meandriniformis*.

Variety *hirsuta*.[1] This (Pl. XVI, fig. 4) is distinguished by the enormous length of the tufts, and the great number of the orifices and channels, rendering this variety exceedingly soft, and the surface particularly cavernous in appearance.

Loc., Nassau, in Soc. Coll.

Sub-species **meandriniformis.**

Spongia meandriniformis Duch. et Mich., Op. cit., p. 33.

This, the well known Velvet sponge of commerce (Pl. XVI, fig. 2), is undoubtedly the form described by Duchaissing and Michelotti. It differs from the preceding in its extreme forms by the absence of the pointed bundles or tufts, and the fibres also are perhaps slightly finer. The absence of the pointed tufts gives a smoother surface, since, as in the preceding variety, these are mainly composed of coarse primary fibres loaded with foreign matter, whereas the connecting or secondary fibres are composed of pure keratose. The surface is also remarkable for the protruding flattened cushions of fibre which slightly resemble the convoluted ridges of a *meandrina*. Sometimes these cushions are transformed into long, solid brushes, or pencils of fibre.

Loc., Biscayne Bay, Nassau and Key West, in Soc. Coll.; Island of Fernando Noronha, Havana, Mauritius, in Coll. Mus. Comp. Zoology.

Variety *barbara*.

Spongia cavernosa Duch. et Mich., Op. cit., p. 30.

" *barbara* " " " " p. 31.

The irresolvable uncertainty which surrounds the identity of the actual form described under this name by Lamarck, has led me to think that its utter abandonment would be the best course to pursue. That any two independent workers should describe precisely the same form by this name seems to me improbable, in consideration of the fact that

[1] *Spongia utilis* Duch. et Mich. I have not been able to identify this species or variety, but I think it may be the same as the variety "*hirsuta*" or "*porosa*" of *Spongia gossypina*.

no peculiarities are given by any one which could establish its identity. Esper's figure may possibly enable some one to settle this question, but I have seen no specimen which might be considered precisely identical. Dr. Ehler, in his recent review,[1] appears to have decided that Esper's original specimen belonged neither to the *Spongia cavernosa* of Duch. et Mich., or to the *Cacospongia cavernosa* Schm., and my own observations have led to the same conclusion.

It was with the greatest difficulty, also, that I could come to any conclusion with regard to the form described by Duchaissing and Michelloti. It may be well to remark, also, that the surface in this figure is even more wretchedly drawn than many of the others, and this greatly increased the labor of obtaining a satisfactory identification.

The principal characteristics of the form and surface ally this form so closely with sub-species *meandriniformis*, that I can only separate it as a distinct variety. The forms of the specimens (Pl. xv, fig. 5) in our collection are more spreading than is usual in that variety, and the texture is quite as soft, though denser, perhaps, when the skeleton is dry. The projecting cushions of fibre are similar in form to those of variety *meandriniformis*, but are joined together in larger masses by a tissue of fine superficial threads, which also are often less dense, and simply bridge the intermediate channels. This, and the tortuous and rather shallow character of the channels, gives the surface a smoother aspect than is common in the skeleton of *meandriniformis*. The oscules are very large, and have a peculiar ragged aspect in dried specimens. They look as if some one had made them by repeatedly running a knife into the animal while it was drying, and then omitted to clean out the interior thoroughly, leaving sharp pinnacles of dried sponge cuttings projecting inwards, sometimes so as to fill the centre, but oftener sticking out around the centre of the aperture, and more or less completely joined to the wall of the canal. This characteristic ragged look is sometimes also to be seen in the oscules of sub-species *gossypina*, but never so decidedly. The typical form is also known commercially as "Velvet Sponge."

Loc., Key West, Nassau, in Soc. Coll.

Sub-species cerebriformis.

Spongia cerebriformis Duch. et Mich., Op. cit., p. 32, pl. 3.

Variety *typica*. The aspect of this species, commonly known as one of the "Grass Sponges" is very similar to that of *Spongia agaricina*, sub-species *corlosia*, var. *typica*. The difference consists principally in the aspect of the surface. This is broken up by parallel longitudinal ridges of irregular length on the sides, each ornamented with one or two lines of tufts. These ridges extend on to the upper surface, giving them a markedly radiatory arrangement. The larger orifices are situated in rows in the channels between the ridges. The specimen figured (Pl. xv, fig. 7) is probably in every way identical with that figured in Duchaissing and Michellotti's work.

Variety *plana*. This variety (Pl. xv, fig. 8) seems at first to be identical with *complanata* and *circularis* of Duch. et Mich., but the figure given of *Spongia circularis* and the descriptions of both species, are not favorable to such an identification. The general form of the typical variety is very much compressed, being hardly ever more than three inches in depth, without much reference to the breadth; some specimens of this depth being eight or nine inches in diameter, while others are only two or three. Large specimens are very

[1] Die Esperschen Spongien. p. 6.

apt to have the interior pierced by galleries, which often honeycomb a sponge which seems superficially to be very solid. The top is covered by a remarkably thick membrane, which in many specimens is not pierced by excurrent apertures on or near the edges. This gives a partially smooth zone or border, which, when it is present, contrasts in a remarkable manner with the apertion of the central part. The whole of the top, with the exception of the border, is perforated by excurrent apertures of small size, so numerous that they are often separated only by the dividing wall common to the contiguous tubes. The sides may either be furrowed or have a pitted appearance, according to the presence or absence of tufts of fibres, but in no case are the furrows divided by such regular ridges as in variety *typica*.

Loc., Florida, in Soc. Coll., and Kingsmill's Islands, in Coll. Mus. Comp. Zool.

Variety *divisa*. The form is divided in this variety into several large flattened lobes, which are apt to have a rougher surface on the sides and be more cavernous than the colonies of the typical variety. The length of the tufts gives a furrowed aspect to the upper side of the skeleton in some specimens. According to Dr. Palmer's observations, the color of the animal while living is black, and it is found upon hard irregular bottom or corals in about two feet of water at low tide.

Loc., Key West, Biscayne Bay, in Soc. Coll., and Stono Inlet, S. C., in Coll. Mus. Comp. Zoology.

Variety *Mexicana*. This variety (Pl. xvi, fig. 28) approximates closely in form to variety *divisa*, but the loose open texture of the inner side, due to the number and close approximation of the excurrent orifices is replaced by a closer web, in which only few apertures are visible. It is in fact more like sub-species *corlosia* in this respect; the texture and surface, however, are like those of this sub-species.

Loc., Vera Cruz, in Mus. Comp. Zoology.

Variety *caliciformis*. The external surface (Pl. xv, fig. 9) of the dried specimen, and even the cavernous character of the interior, with the large openings of the galleries perforating the sides, are the same as in the preceding varieties. The differences are due to the form, which is regularly vase-shaped (Pl. xvi, fig. 30), and to the surface of the infundibuliform side. This last is not only perforated by numerous contiguous excurrent orifices, but also by many of the galleries from the cavernous interior. This gives to a portion of the upper surface a very much more rugged or broken up aspect than is found in the preceding varieties.

There are three skeletons of this form, two from Nassau, and one, locality unknown. The two from Nassau exhibit a light yellowish brown skeleton, nearly as harsh to the touch as that of *Spongia agaricina*, sub-species *dura*. One of the Nassau specimens has the inside of the cup of much denser structure than in the others, and the rim perforated. This transposition of the area occupied by the excurrent orifices is, however, not the only solecism. The surface of the sides is divided by deep channels into primary and secondary tufts, precisely similar to those of the following variety.

Variety *obscura*. This (Pl. xvi, fig. 29) is found at Nassau, and also occurs at Key West; at least the color of some skeletons indicate that locality, the fibres being harsh and deep brown to reddish brown near the centre. The surface is rounded, and pierced by numerous orifices surrounded by ridges and tufts of considerable length. The aspect of these is such that I formerly referred this form to variety *hirsuta* of sub-species *gossypina*. This variety also occurs at the Bermudas, according to Mr. Goode's collection. A collec-

tion of waste sent home by Mr. Saltonstall contained a number of this variety which conclusively settled the question of the affinity of the species; some of these specimens are forms of *gossypina*, and some of *cerebriformis*.

Spongia agaricina Pall.

Spongia agaricina Pall. (Esper Pflanzth., 2, pl. 14).

Sub-species **Zimocca.**

Spongia Zimocca Schm., Op. cit., p. 23.

This species varies like *Spongia officinalis*, but the cup-shaped varieties are much flatter and broader, and from these there are all imaginable variations. The interior may rise into a prominent bulging dome-like centre, the excurrent orifices still presenting, however, the pitted aspect, and the surface the hirsute structure and dark color so characteristic of the species (Pl. xvi, fig. 22). These solid forms may be more or less lobed, and continue to grow until a very irregular lobate form is produced, which is almost a true branching stock. The qualities follow the same law of variation, the irregular forms being generally the coarsest, and these approximate in a remarkable way in quality and the aspect of the orifices and surface to the finer qualities of the American varieties.[1] The typical form, as figured by Esper, has all the peculiarities, including even the dark color of the skeleton, which is characteristic of this species; and since Dr. Ehler has referred it to this genus I do not think there can be any reasonable doubt as to the proper limitation of Esper's name.

Sub-species **dura.**

The fibres of all the American forms are considerably coarser than those of *gossypina* in all of the normal forms, but of course in some varieties this distinction does not hold.

1. The primary and secondary, or connecting fibres are equal in size. The former are continuous below, and single. The latter have a precisely similar aspect, and run parallel with the primaries for considerable distances before bending laterally to anastomose with others and form the mesh of the connective tissue. They are, however, never loaded with debris, but the mesh is, in consequence of this peculiar structure, long and narrow, and mostly arranged vertically.

2. Primary and secondary fibres project in tufts above the surface, and are connected by a third system of short horizontal fibres, as in the Stelospongas group.

Variety *typica*. This sub-species, the form known in commerce as Hard-Head or Honeycomb reef sponge (Pl. xvi, figs. 24–25, and Pl. xv, fig. 6) is very closely allied to sub-species *gossypina* in some respects. The color is darker and the texture denser than in the latter, and yields only to considerable pressure between the fingers. The surface presents large tufts of fibres, and between them canals, resembling in this respect the surface of variety *meandriformis* of sub-species *gossypina*, but differs in the minor tufts of fibres. These are more minute than in *gossypina*, and present a more hirsute or bristly aspect. The typical commercial forms are not to be found in the shallower waters, they being mostly gathered beyond the depth of sixteen feet. The color, as reported by Dr. Palmer, is black when living, with a brownish tinge. He also says that they are usually more isolated than *gossypina*, and not closely associated with other sponges, though growing upon the reefs. The largest observed was probably about six inches high by sixteen to twenty inches

[1] The specimen figured is one of the exceptions to this rule, since it has a skeleton of remarkably fine texture.

broad. Both this species and sub-species *gossypina* have a tendency to grow up into rotund forms, which are, however, smallest at the base, and sometimes quite contracted at this point, especially if the object or area to which they are attached is small enough to limit the growth of the diameter of the base. The varieties are many, though not of a marketable character, and therefore not so well known to spongers as those of *gossypina*.

Loc., Biscayne Bay, Nassau, in Soc. Coll.

One very remarkable specimen exists in the Collection of the Academy of Natural Sciences of Philadelphia, about a foot high and a foot broad at the base. It is a huge pile, so to speak, of the single fistular forms, like a bee hive. The depressions between the cone-like orifices are very deep and irregularly arranged in lines from the base to the summit. The surface is, however, the most interesting part. The primary fibres project in bundles of small size, very evenly distributed over the entire surface. They are both larger and longer than the similar bundles in the adult forms, and resemble closely those of sub-species *cerebriformis*. It required a close examination of many specimens in order to show any essential differences of surface, though the adults of these two forms are very distinct in this respect.

Loc., Bahama Islands.

It is not possible to distinguish some of the varieties of the Hard Head from those of the Yellow sponge. The irregular forms and looser textured varieties approximate to those of the sub-species *corlosia*, both in structure and aspect, and this is the case also with the young of many varieties in both series.

Sub-species **punctata.**

In this sub-species (Pl. XVI. fig. 23), the typical specimens have often a close resemblance to sub-species *tubulifera* in form; and the almost total absence of the larger primary bundles with their interstitial channels, increases this resemblance; the apertures are also frequently deeply indented on the outer side, as in that species. This form, however, is denser than any other, and the bristly minor bundles are in greater profusion and of greater length than in other varieties. The apertures also are more numerous than in the preceding variety, and about three-eighths of an inch in diameter. They open also superficially, instead of being buried in the channels between the large projecting cushions of the skeleton.

Loc., Nassau, in Soc. Coll.

Variety *densa*. In this variety (Pl. XVI, fig. 27) all shades of difference and transition are represented, until we come upon a form which is identical with sub-species *corlosia*. This can, however, like other varieties, be distinguished from that species by the number and small size of the apertures, their scattered distribution over the whole surface, and the toughness and darker color of the skeleton. The minor or superficial bundles of bristle-like fibres are hardly seen at all on the upper side of some specimens, and in all they are much less marked than in the preceding variety. This gives the upper surface a particularly smooth or even aspect, which is, however, broken up by numerous superficial anastomosing canals, which become more or less parallel upon the sides.

Loc., Nassau, in Soc. Coll.

In all of these varieties the forms may vary greatly. In the first they seem quite constantly club-shaped, or at least round clumps taller than they are broad, and narrower

at the bottom than near the top, which is rounded; in the second the same form is the typical one, but there are also some very flat table-like specimens; in the third the same forms occur with others, which manifest a tendency to throw out branches. In one or two specimens also from Nassau, which may be referred to this variety, the surface is precisely similar to that of *discus* or *tubulifera* in general appearance, but a close examination shows the numerous and peculiar tufts of primary fibres which distinguish this species.

Sub-species **corlosia.**

Spongia corlosia Duch. et. Mich., Op. cit., p. 31.

This, which is popularly known as the "Yellow Sponge" of commerce, was at first confounded by me with *Spongia dura*, the "Hard Head" (Pl. XVI, fig. 24), but an examination of a full series of forms showed that very considerable differences exist in the texture, though superficially there is little or no distinction in the aspect of the surface. Dealers can identify these varieties instantly by the color, which is usually lighter than that of the "Hard Head," and by the touch, the "Yellow Sponge" yielding much more readily and feeling less harshly under the fingers. These characters, however, only apply to the normal head-like forms and some of the varieties; many forms cannot be placed in either one or the other of the two groups with any certainty.

Loc., Nassau, in Soc. Coll.

Variety *gossypiniformis*. This is the most remarkable variety (Pl. XVI, fig. 26), and it approximates to *corlosia*, not only in external aspect, but in form and color and general texture. The form is similar to the fistular varieties, with one or two very large orifices above, and the color of skeleton is much lighter than that of the other varieties. It is also permeated by larger canals than in other varieties, and thus the general texture approximates more closely to the softer and more porous character of this sub-species.

Loc., Nassau, in Soc. Coll.

Variety *fusca*. The young, and some few older specimens which I have referred to this form from Key West, have the surface of the skeleton on the sides more like those of sub-species *dura* (Pl. XV, fig. 11; Pl. XVI, fig. 31). The skeleton of many of the young also presents characteristics almost identical with those attributed by Duchassaing and Michelotti to sub-species *cerebriformis*. The top surfaces are, however, not so similar; they being almost devoid of the broken aspect so characteristic of sub-species *cerebriformis*. The shape is pretty generally like that of an inverted, truncated cone; the top flaring more or less in all specimens, and either slightly gibbous, or flat. The excurrent orifices which occupy this area are but slightly protuberant, and there is no such marked zone between them and the sides as in sub-species *cerebriformis*, variety *complanata*, nor are the apertures, even when small, so numerous, or arranged according to any describable plan. The color in a living state is black, and the largest specimen observed by Dr. Palmer was about eight inches in height. This collector also reports it as found growing almost exclusively upon coral and other sponges. One young specimen has a projecting branch in every respect identical with the following.

Variety *elongata*. This (Pl. XV, fig. 10) has an elongated form, sometimes slightly branched, the branches thick and club-shaped, but never fistulose. The larger number of the specimens are young, and were collected from Biscayne Bay, and named by Dr. Palmer "Small Hard-Heads." This commercial designation is, however, of doubtful correctness.

There is, it is true, considerable resemblance to sub-species *dura*, the true "Hard-Head," but there are also some differences. The surface and structure of the skeleton and fibre are quite distinct. When living the surface probably closely resembles that of *fusca* and *dura*, since we find here, as in those forms, groups of the round, small, incurrent openings.

The smoother aspect of the surface where it is covered by the dried skin, distinguishes this variety at once, but the surface of the skeleton is (Pl. XVII, fig. 1) broken up by the ridges into hexagonal or angulated cells of small size, which contrast forcibly with the more irregular and broken surfaces of other varieties. This is due to the closer approximation of the primary tufts and ridges which support the membrane.

Loc., Biscayne Bay, Key West. Habitat, reef, two feet of water at low tide, and deeper.

Spongia vermiculata Duch. et Mich.

Spongia vermiculata? Duch. et Mich., Op. cit., p. 35.

Spongia lacinulosa Duch. et Mich., Op. cit., p. 35, pl. 4, fig. 4.

1. The primary fibres are very coarse, numerous, closely set, but not continuous below. They project, however, in tufts above the surface, and are united by numerous short connecting fibres.

2. In several instances in varieties *papyracea, negligens* and *mollicula,* the primary fibres are continuous below.

3. The mesh of the connecting fibre is exceedingly small and irregular, giving the sponge extraordinary density and hardness. The primary fibres are continuous, coarse, and loaded with debris, and run across the mesh of the connecting tissue like small ropes laid on thread lace.

4. Primary fibres in the same sponge sometimes form fascicles or tufts like those described above, and are sometimes single.

Variety *lacinulosiformis*. Why Duchassaing and Michelotti should have selected this particular species as the *lacinulosa* of Lamarck, is not plain to me, since Pl. 16 of Esper only illustrates a very common variation of the surface in *Spongia officinalis*, and an aspect of this part which might be anticipated in any species. According to Lamarck's first edition, he regards the whole of *Spongia officinalis* Esper as equivalent to his *Spongia lacinulosa*, and particularly designates the same localities, the Red Sea and the Indian Ocean.

The oscules are numerous, and their prominence gives the whole mass a sub-fistulose aspect. The tufts are developed in the greatest abundance, and are often themselves more or less dendritic. The whole aspect of the skeleton is distinct from that of *Spongia lignea*; it is not so dense, and the fibres are coarser and darker colored, resembling somewhat in their appearance those of the finer species of Spongelia.

Loc., Coast of Florida, in Yale Coll.; Teneriffe, in Soc. Coll.

Variety *vermiculatiformis*. This forms differs from the preceding variety chiefly in the texture, which is more open, though as stiff to the touch. The fibres themselves are very stiff, as in some specimens of the preceding variety. The surface is apt to be smoother, as in variety *levis* of *Spongia lignea*, and the whole aspect of the mass lighter, very irregular in form, and with oscules not noticeably elevated in the dried skeletons.

I have called it *vermiculatiformis* from its resemblance to the description of *vermiculata* by Duchassaing and Michelotti, with which it may be identical.

Loc., near Ft. Pierce, mouth of Indian River. Found dried on the beach.

Variety *negligens*. The Key West specimen (Pl. XVII, fig. 4) of this variety is so cavernous that it resembles an irregular roll or bundle of anastomosing branches. The surface is smooth, but the skeletal structure is very similar to that of variety "*vermiculatiformis*."

The Nassau specimens (Pl. XVII, fig. 2) are more solid, and exhibit large oscules which are absent in the preceding. They are also very cavernous, but the epidermis of the mass when living evidently covered all the internal inequalities caused by the channels. This variety may possibly, and in fact the whole species may be in part the *Caccospongia mollior* Schmidt.

Variety *papyracea*. A specimen labelled "East Indies," from the Collection of Yale Museum, has a dendritic form, but otherwise, in texture of skeleton and general aspect of the fibres and their arrangement, it resembles variety "*negligens*."

Sub-species **mollicula.**

There are very interesting specimens of this form from Zanzibar, Coll. Peabody Academy of Science, and Aspinwall, Yale Coll. The fibre is of the softest and finest description. The mass is also much denser than in variety *negligens*, and the texture excessively irregular. It is quite possible that this variety may turn out to be a distinct species. The surface is very similar to the smoothest and densest varieties of sub-species *tubulifera*. The interior is not at all cavernous, and the surface is very irregularly seamed by crooked channels and pitted with oscula of small size.

Sub-species **Cookii.**

Specimens of the typical variety of *Cookii* have the surface covered by coarse tufts, and in the same specimens the fibres differ greatly in size, being in some parts very coarse and in others very fine. The color also varies from light yellowish brown to dark red. The dried skeleton is harsh, but elastic and not easily broken by pressure, though very readily torn apart, differing in this respect very much from the typical Spongiæ.

Loc., Zanzibar, in Coll. Peabody Academy, and Soc. Coll. Collected by Mr. Caleb Cook, of Salem.

Variety *ditelliformis*. The general texture appears to resemble that of *Cookii*. The number and arrangement of the canals, their irregularity, and the complete manner in which the interior was honeycombed by them, together with the veil, are, however characteristic, altogether distinct. There is also a complete absence in all parts of any primary fibres properly so called, the whole texture being typically Spongian. The veil is composed of the internal fibres, which are deflected and closely interwoven in the same plane, bridging over larger internal openings and canals, and reducing the apertures to a very small size. This specimen shows that the Ditelian veil may in its most complete form be possessed by true Spongia as well as by Spongelia and other genera.

Loc., Island of Fernando Noronha, in Coll. Mus. Comp. Zool.

Variety *tectoria*. This variety is dendritic in the two specimens which were examined. The internal texture was similar in every respect to that of the preceding variety, but the veil was the marked characteristic. It extends over the whole surface, and the mesh is circular or cellular, very much smaller than in the interior, and composed of much finer threads, here and there underlaid by the coarser fibres of the interior.

Loc., Pacific, U. S. Ex. Exp., in Yale Coll., and Coll. Mus. Comp. Zool.

Another specimen, in all probability belonging to this form, in the Yale Collection, has a precisely similar mesh but no veil. The mesh is small and remarkably regular, and there are no well marked primary fibres. No locality.

Spongia lapidescens Duch. et Mich.

Spongia lapidescens Duch. et Mich., Verhand. Maatsch. Wetensch. Haarlem, 1864, 21–2, p. 34. Spong. de la Mer Caraibe.

This species is very closely allied to the typical variety of *Spongia vermiculata* in the aspect of the surface, and general texture and hardness of the skeleton; this is especially the case with the fistulose varieties. The whole aspect of the surface, the tufts and their structure, show considerable affinity with sub-species *cerebriformis*, but on the other hand, the extreme density of the skeleton and stiffness of the fibres seems to indicate that a separation is necessary. The permeability of the outer membrane to debris of all kinds also favors this conclusion.

Variety *typica*. The entire surface (Pl. XVII, fig. 3) is covered by tufts of fibres, which are parallel and closely appressed, but rarely connected by lines of secondary fibre. These bundles in some specimens may be very thick and brush-like. They approximate to the aspect of the surface in sub-species *Mauritiana*, which has similar large bundles of fibres, but of a more complicated or net-like structure similar to the body of the skeleton. The peculiar structure of these tufts is shown by the chenille-like aspect of the tops, due to the projecting free ends of the primary fibres.

Loc., Havana, in Coll. Mus. Comp. Zoology; Florida, in Soc. Coll., and Hayti, in Coll. Peabody Academy, Salem.

Some specimens of this variety have tufts of all shapes and sizes, and one is nearly smooth on one part of the surface, showing very prominently the small round oscules peppered in between the tufts. This leads into the next variety.

Loc., Havana, in Coll. Mus. Comp. Zoology, and Soc. Coll.

Variety *tetheaformis*. The name alludes to the faint resemblance to a dried Tethea, due to the similar aspect of the tufts of parallel fibres and the bundles of threads in a dried specimen of that genus. These are very long and very closely set, often joined into crests, parallel and quite sharp above, differing in this respect from the blunt aspect of the bundles on the cracked surface of a dried specimen of the siliceous genus Tethea.

Loc., Havana, in Society's Coll., and in Mus. Comp. Zoology.

Variety *intermedia*. The texture is generally somewhat looser, the oscules larger and the tufts longer and more irregular, varying in the same specimen from forms comparable with those of the typical variety to those in which they assume a fan-like outline, and are composed of only a thin layer of fibres.

Variety *turrita*. In this variety (Pl. XV, fig. 12) the parallelism of the fibres of the superficial bundles is less noticeable than in the preceding variety, these parts being, as in the generality of the Spongiæ, composed of fibres more or less interwoven. The fan-shaped or flattened tufts, however, usually have the fibres parallel, and the surface is similar to that of the other varieties, with the following exception. Large oscules occur irregularly scattered over the mass, which are elevated upon fistular projections of the skeleton. Near the apertures the walls of these are remarkably thin, and built up of the same tissue as the body of the sponge, but with a more regularly elongated mesh and more decided

development of primary fibres. I am informed also by Mr. Goode, that this sponge is apparently very abundant, and is the principal useful sponge found in the lagoons of Bermuda. It is, however, too coarse for anything but the roughest purposes.

Loc., Bermuda, in Coll. Wesleyan University, Middletown, Mass., and Soc. Coll.

Sub-species **dentata.**

This form (Pl. XVII, figs. 6, 7) is represented by only one specimen, one of the most remarkable species I have yet seen. The whole surface is covered by a hard, even crust, similar to the tough epidermis of Geodia, and resembling it in color. It extends over the whole external surface, both above and below, but is not found in the endoderm lining the canal system. Microscopical examination disclosed the curious fact that it was probably due to the great extent with which the epidermis of the animal while living was loaded with fine calcareous mud. The whole figure, which is of an irregular outline about 300 mm. in diameter, is only about 40 mm. in the thickest part, and is covered above as in variety *typica*, by the usual tufts. These, however, are very regular in distribution, of small size, round, and quite pointed. There are also larger oscules sparsely scattered over the surface with crater-like walls of about 5 mm. in height. The figured specimens are parts of a fragment of a large colony in the Collection of the Museum of Comp. Zoology.

Loc., Havana, in Mus. Comp. Zool. and Soc. Coll.

Sub-species **Mauritiana** Hyatt.

This variety (Pl. XVII, fig. 5) is remarkably cut up by internal channels which permeate the substance in every direction. These are quite large, elliptical in outline, and about a quarter of an inch in diameter, and give the sponge a very rough aspect on the surface, which in perfect specimens rises into prominent tufts and ridges between them. The fibres are remarkably inelastic, and the whole mass unyielding to the touch, but not brittle, friable, or easily broken.

Loc., Mauritius, in Coll. Mus. Comp. Zool. and Soc. Coll.

Variety *Pacifica*. This is an incrusting form, permeated by similar large channels which, on account of the thinness of the mass, give the sponge a perforated aspect when held up to the light. The surface is very rough, and is cut up by parallel ridges and irregular shaped elevations, bearing either rows or bunches of projecting fibres.

Loc., Pacific Ocean, U. S. Ex. Exp., Yale Coll. and Society Coll.

Variety *decidua*. This variety, although precisely similar in structure to the variety last described, differs slightly in the aspect of the surface. The projecting ridges are transformed into bunches, sometimes solid and sometimes fringed by the projecting free ends of primary fibres. There is a tendency also in parts to extend these into a sort of velum covering over the intermediate spaces. This is particularly the case upon the lower side of the specimens from Mauritius, and a part of the upper surface in the Havana specimen.

Both specimens are in the Coll. Mus. of Comp. Zool.

Stelospongos Schmidt.

This interesting group, described by Schmidt, is readily distinguished in most species by the compound structure of the primary fibres, but in others the primary fibres are not so closely associated. The primary fibres are associated in bundles, and closely connected by secondary fibres. Sometimes these primary fibres are nearly parallel, sometimes branching

at intervals into a succession of fan-shaped figures. These appear upon the surface of the species which possess this mode of growth as flat, fan-shaped, or fascicular bundles, with a narrow mesh formed by the thickly set and horizontal secondary fibre. In some species the bundles, growing broader towards the surface, would thus become of enormous size if there was not a secondary system of branching which separates the large ones into two or three smaller bundles. There are none of these, properly speaking, in some other species, but only closely connected sheets of parallel primary fibres with the usual close net work formed by the approximation of the horizontal secondary fibres; these lead into the genus Spongelia, between which and this genus no definite and constant differences, applicable to all the species without reservation, have been found in the skeleton.

In all the species I have yet seen, the general system of connecting tissue formed between the bundles by the secondary fibres has a remarkably loose and open texture. Of course there would naturally be a great variation in such a characteristic, but as compared with either Spongelia or Spongia, this portion of the skeleton is very loosely put together, and the mesh is usually either of a very irregular form, or composed of horizontal secondary fibres united by an independent series of shorter vertical fibres. The bundles of primary fibres radiate from the interior outwardly, and with the connecting tissue of secondary fibres form a mass of more or less perfect tubes also radiating outwardly, as in Spongelia; and at intervals horizontal canals are formed which connect these tubes with each other, and are of about the same diameter.

Stelospongos Maynardii Hyatt.

The typical specimen (Pl. XVII, fig. 21) of this species is fistulose, but with very thick walls below; the greatest diameter is about 110 mm., height about 150 mm. The central canal is largest at the opening, which is about three-quarters of an inch in diameter, and the walls are composed of enormous bundles of primary fibres, which sometimes attain a thickness of 7 mm., though generally not more than half that in diameter. The bundles are irregularly rounded fasces of primary fibres, bound together by short, thick, secondary fibres, so closely arranged in parts that the intermediate spaces appear like the rounded holes in a sieve, or cullender, while in other parts of the same bundle they may be so wide apart that they resemble more nearly the square spaces between the rounds of a ladder. The primary fibres are always very thick, closely set, and often branch at intervals. This latter characteristic causes a constant increase in the thickness of the bundle, and these would soon attain an unwieldy size if they did not, as they grow outwards, again divide at intervals into two or three diverging fasces. All of these are bound together by a net work of secondary fibres, much coarser than those connecting the primary fibres inside of the bundles, and the mesh is exceedingly large and loosely looped up between them. This connecting system and the bundles of fibres together, form the wall of an unusually regular system of tubes leading into the central fistular cavity. The external openings of these are thickly set, and may vary from 7 mm. in diameter to half that size. The surface of the skeleton is excessively rough, on account of the great size of the fibres and bundles, the number and size of the orifices and the loose arrangement of the connecting fibres. Perhaps this is even more to be attributed to the irregularity caused by a system of very deep channels connecting all the smaller orifices. These break up the surface and give the bundles the aspect of standing out very prominently from the surface,

whereas, in all the spaces between the orifices and this system of channels the connecting secondary fibres are almost even with the tops of the bundles of primary fibres.

Loc., Key West., in Soc. Coll.

I have also received, by the kindness of Prof. J. W. P. Jenks, a specimen (Pl. XVII, fig. 22) of a distinct form, but which at present I prefer merely to mention in connection with the above. It differs from *S. Maynardii*, solely in the smaller size of the bundles fo primary fibres, their close approximation, and the greater quantity and density and smaller mesh of the connecting skeletal tissue. The specimen has the fistular form, and the locality is unknown.

Stelospongos levis Hyatt.

The forms (Pl. XV, fig. 16) of the two specimens examined were rounded and fistular, the height being about 108 mm., and the greatest diameter 70 mm. The whole base of *S. Maynardii* rested upon the rock, whereas this specimen has a thick, short pedicle, and the walls of the fistular aperture are thin and fringe-like, instead of thick, as in *Maynardii*. In the skeletal structure there can be no close comparison, except in the generic characteristics. The radiating primary fibres form flattened, fan-like expansions, which are particularly noticeable on the surface. The reticulations are more generally open or ladder-like than in *Maynardii*, and the whole, as well as the connecting net of secondary fibre, much finer and denser than in that species; and the incurrent tubes more numerous and closely set, and less distinctly divided by the tissue of connecting secondary fibres. The apertures are not connected by any special channels, and the surface is therefore even, though roughened by the projecting fan-like tufts of primary fibres.

Loc., Pacific Ocean, U. S. Ex. Exp., in Yale Coll., and New South Wales, in Coll. Acad. Nat. Sciences, Philadelphia.

Variety *rotundus*. The two specimens (Pl. XVII, figs. 23–24) examined were erect upon short, thick, pedunculer bases. One, however, has a gibbous fistular form, though the central aperture is quite small, and is accompanied by several smaller ones running in a line across the summit. The other is broader near the top than at any other part, and has several excurrent orifices irregularly placed, partly on the top and partly on one side. The structure is denser than in typical *levis*, owing to the close proximity of the bundles of primary fibres. These have, however, the same structure, branching at intervals into fan-like expansions of lattice work, resembling those used by florists for vines and flowers; they project considerably, and are so closely set that the whole surface has a characteristically shaggy aspect. The tissue of connecting secondary fibres is almost as unimportant and as open as in *Maynardii*.

Loc., Phillip's Island, off Port Phillip's Head, Australia, in Soc. Coll.

Stelospongos friabilis Hyatt.

In the single specimen examined, the principal difference lies in the slight distinction between the tissue of the primary fibres and those of the secondary. Both are much finer than in any of the preceding, and present a vesicular aspect. They are also so mingled together in parts of the specimen that the observer fails to distinguish between the primary fibres and the connecting tissue of secondary fibres. The bundles of primary fibres become apparently simple lines or columns formed by a denser aggregation of the connecting tissue. In other parts of the same column or bundle the primary fibres can be singled

out, principally, however, owing to the fact, that they are more or less charged with introduced material. The bundles project above the surface, and are arranged along the sides or as divisions between the channels which connect the mouths of the numerous tubes, which penetrate to the surface without any special order of arrangement. The bundles are smaller than in any of the preceding species, and, in fact, are really in some parts only single fibres, as in Spongelia. This minuteness, their stiffness and projecting character, make the surface look as if it were set with bristles.

Loc., Zanzibar, in Coll. Peabody Academy, and in Soc. Coll.

Stelospongos cribriformis Hyatt.

The surface of the skeleton presents precisely the aspect of Spongelia. This is owing to the regularity with which the bundles of fibres occur upon the surface, and their small size, as well as to the regularity with which these are connected by ridges of associated secondary fibres; which also, on account of their minute size, resemble the single secondary fibres of Spongelia. The linear or radiatory arrangement of the associated primary fibres forms long and more or less continuous tubes penetrating into the interior; these are so perforated or pierced by connecting holes through the skeletal walls, that they appear very irregular. These holes are nearly, or quite, equal in diameter to the tubes, and entirely interrupt the primary fibres. The division walls between these holes are formed by large secondary fibres stretching across from one set of primary fibres to the next. These are again connected by a third set of fibres which run from one horizontal secondary fibre to the next. Sometimes this regularity is not apparent, and only an irregular network is visible, in which no distinction can be made between the horizontal and connecting or tertiary set of fibres. In some parts of the same sponge, also, all regularity is lost, and the whole is a network of irregular size and shape, similar to that of the true Spongiæ. This is especially the case with the following.

Variety *stabilis*. In this variety (Pl. xv, fig. 15; Pl. xvii, fig. 25) the tissue is unusually dense, and the surface is not marked, except in spots, by the usual tissue of cellular aspect, due to the opening of closely contiguous tubes upon the surface of the skeleton. The primary fibres are also indistinct in the interior, and a considerable part of the skeleton has the irregular mesh just described. The primary fibres are shown only upon one side of the surface, and here, also, tubes are found.

Loc., Key West, in Yale Coll., Havana, in Coll. Mus. Comp. Zool.

A Havana specimen combines the structure of the former with that of the next variety, having a similar surface but more decidedly tubular, a hollow interior and an intermediate size to the mesh of the skeleton. There is also a specimen from Nassau in the Society's collection having something of this intermediate character, though perhaps, strictly speaking, it ought to be included in the next variety.

Variety *typica*. The surface of this sponge, Pl. xv, fig. 14, is more perfectly cellular or coral-like than that of any sponge I have ever seen. The vertical walls between the tubes are formed of very dense tissue, and there are but few horizontal threads crossing the mouths of the tubes; in fact, in some parts of each colony none at all. The mouths of the tubes vary greatly in diameter, but in some specimens reach the diameter of 5 mm. The intimate structure of the skeleton is distinct from the Key West specimen of variety *stabilis*, but is only a less variable form of that found in the others of the same variety.

The walls of the tubes are made up of vertical fibres not very wide apart, and connected by closely approximated secondary fibres. The primary fibres are gathered into groups of two or more, standing in the same plane, though occasionally, at the corners of the tubes, solid groups are formed by the branching of the fibres; then either new tubes arise between the branches, or solid fasces are formed, as in *Stelospongos Maynardii*. The form, instead of being solid and crest-like, as in variety *stabilis* (Key West specimen), is like that of the Havana representative of that variety.

Loc., Havana and Hayti, in Mus. Comp. Zool., and in Soc. Coll.

Stelospongos Pikei Hyatt.

The skeleton of this species is represented by many beach-worn specimens collected at Mauritius by the English Consul, Col. N. Pike, [Coll. Mus. Comp. Zoology and Soc. Coll.]. They are highly colored, of a yellowish brown hue, and very hard and inelastic. The surface presents the aspect of Spongelia. The fibres are apparently single, and project in the form of stiff bristles, about 5 mm. long, where they have not been worn off by friction on the beach (Pl. XVII, fig. 20). The tissue between is dense, and is penetrated by apertures of variable size, irregularly scattered over the surface. Upon closer examination, it becomes apparent that most of the fibres are not single, but really compound bundles. The fibres composing these may be so closely joined in the interior that it requires critical examination to detect their compound character, or they may be quite wide apart. The connecting tissue of secondary fibre has a very close and dense, but irregular mesh, resembling in this respect the connective tissue of *Verongia fistularis*. In some parts of some specimens a very remarkable and characteristic variation was observed, similar to the Diteliform variation of the surface previously described. A web of very fine white fibres crosses the larger meshes, and connects the dark yellow, horn colored fibres of the original skeleton. This is so fine and so dense that it has a downy or fleecy look on the cut surface of a section.

Stelospongos intertextus Hyatt.

This species is represented by only one specimen, in the Collection of the Museum of Comparative Zoology, from the Mauritius. It resembles *Spongelia enormis* in form, but has only a few scattered excurrent orifices on the dried skeleton. The texture is remarkably light, and very closely resembles that of Spongelia. Upon close examination, however, it can be seen that the primary fibres branch frequently; that these branches run parallel for a considerable distance and are loosely united by short secondary fibres. The general connecting tissue of secondary fibres resembles the irregular texture of some species of Spongelia in which no very distinct tubes are formed. The arrangement of the primary fibres on the surface, at first led me to suppose that this might be the young of some variety of *Spongelia enormis*. If the primary fibres were single, I should not feel justified in separating it; but I have not, however, so far found that the compound character of the fibre is a characteristic of the young of either Spongelia or Spongia; and, therefore, until we know more of the animal, it seems to me safest to classify the debateable species according to the character of their primary fibres. Thus, though this is a true Spongelia in general aspect, lightnesss and elasticity of texture and form of the mesh of the general tissue of secondary fibres, I prefer to consider it a member of the genus Stelospongos on account of the characteristics of the primary fibres.

Spongelia Ndo.

Dysidea (pars) Johnson.

Spongionella Bow.

Caccospongia (pars) Schmidt.

This genus is readily distinguished from Spongia in the dried specimens of most of the species by the character of the surface. It is made up of contiguous, sunken, angulated areas, giving the surface a cellular aspect, like that of a cut honeycomb. The cells are not deep, and are formed solely by the shrinkage of the outer membrane over the projecting points of the primary fibres. These are large, radiatory and single; the connecting tissue of secondary fibres is also characteristically regular in most species, and has a large, loose mesh, with the fibres at right angles with the primary fibres. The surface is covered by the projecting primary fibres, and as these are single they give a fine woolly aspect to the otherwise even surface of the skeleton, quite distinct from that of some species of Spongia, or of any other genus. The secondary fibres are clear, and the primary fibres usually, though not in all cases, loaded with foreign matter. Quite a number of the species show exceptional characteristics, but all of them appear to have the characteristic singleness of the primary fibres. Several species show the peculiar modification described by Schmidt as a distinct genus, Ditelia. In one species, *Spongelia velata*, the surface is so completely changed in this respect that I am not entirely convinced that it may not some day justify a new generic group. There is no doubt, however, that what was described first as Ditelia was only a common variation liable to occur in any species of either Spongia or Spongelia, as was subsequently shown by Schmidt himself.[1] The figure of *Spongionella pulchella* Bow., appears to show that this species is a true Spongelian, and the microscopical figure of the fibres and the written description, are very characteristic of Spongelia.

Spongelia incerta Hyatt.

I presume that no one would suspect this specimen (Pl. XVI, fig. 32) of being anything but a pedicellated form of the true genus Spongia. The surface is smoother even than in *Spongelia densa*, the mesh of the fibres very small, and the fibres themselves, like the finest of the Spongiæ, are very elastic and closely woven. I did not suspect the real affinities of this interesting form until a section was made, when the comparatively large primary fibres loaded with foreign matter, and the character of the connecting tissue, became visible. The spaces are filled by the finest fibres forming a close cellular network, much more regular in the form of the mesh than is common among the true Spongiæ. In some parts where the primary fibres approximate, the secondary fibres here and there stretch across, forming the usual ladder-like tissue. The form is flabellate, but very thick in proportion in the centre, so that when seen from above one side is very gibbous. The pedicle is long and rather small, but with the usual dense hard texture of the pedicellated forms of Spongelia. The excurrent orifices are scattered, but the majority occupy the outer edge. The incurrent orifices are very numerous, regularly distributed over the entire surface, and can be plainly seen in the skeleton as round holes. The surface is otherwise perfectly smooth.

Loc., Phillips Island, Australia, in Soc. Coll.

[1] Spongien d. Adriat. Meeres, 1862, and Suppl., 1864.

Spongelia velata Hyatt.

This extraordinary sponge (Pl. XVII, fig. 8) appears at first sight to have very good claims indeed to the distinction of occupying a group by itself. The surface is composed of a veil of finer texture than the interior, which, as in *Spongelia cana*, variety *cincta*, limits the number and diminishes the size of the excurrent orifices. This veil, however, is much more distinct from the body of the skeletal fibres than in any other species in which such a modification of the surface has been observed, and may possibly be quite general and of specific value. This is doubtful, however, and at present it is best to look upon it as the exaggerated development of a variation, probably due to the habitat of the sponge. It is, however, in these specimens, a thin epidermal covering, while in all other cases it is merely a denser aggregation of the secondary fibres as they approximate to the surface. In *Spongia Mauritiana*, variety *tectoria*, a very similar thin covering spreads over the whole surface, but even this is not distinctly separated from the internal fibres, but seems rather a network of minute fibres stretching across the open meshes of the larger fibres, which also form a portion of the veil texture. In this species, however, the internal fibres do not interrupt the smaller fibres, which form the entire substance of the veil on the outer side. The fibres are coarse, the mesh very irregular in shape and size. The arrangement of the primary fibres seems to be in thick sheets, or fan-shaped expansions, which radiate outwards.

It will be seen that it is really similar to the structure of *Spongelia dubia*, variety *excavata*, but with larger and more irregularly shaped canals and less solidity to the skeletal partitions between them. No comparison can be made, however, between the intimate structure of the skeleton itself, this species being in every way so much coarser fibred and more irregular, the color also inclining to dark red or yellow.

Loc., Zanzibar, in Coll. Peabody Academy, and in Soc. Coll.

Spongelia dubia Hyatt.

This species (Pl. XVII, fig. 9) resembles in general aspect the figure of *Dysidea fragilis* Johnst., but the description of the latter seems to show that Johnston really described a true Dysidea, and not a member of this genus at all. The specimens examined from Biscayne Bay of the typical variety, are remarkable for the smooth aspect of the surface, due to the closeness of the projecting points of the primary fibres, which hold up the epidermis and prevent it from settling down between them into the usual pit-like depressions on some parts of the dried specimens. On other parts of the surface the depressions are present, but much smaller than in any other species. The primary and secondary fibres are quite regular in their arrangement, and there is but a slight development of the irregular net-work, so characteristic of some other species. Habitat, shallow waters. Color when living black.

Loc., Biscayne Bay, in Soc. Coll.

Variety *mollior*. This variety, if it really does belong to this species, is described from a type specimen named by Schmidt *Caccospongia mollior?* Schm. The texture is fine, the primary fibres distinct, and the mesh of the tissue of secondary connecting fibres similar to that of the typical variety, but considerably finer. The primary fibres do not project perceptibly above the surrounding surface, which is quite smooth. The form is

tabulate and lobed, with numerous closely approximate excurrent orifices on the flattened upper sides of the lobes, and central part of the mass.

Loc., Florida, and Island of Noronha, Prov. Pernambuco, S. A., in Mus. Comp. Zoology.

Variety *excavata*. This (Pl. XVII, figs. 10–11) differs from variety *mollior* in having a slightly coarser texture with coarser primary fibres, but a similar smooth surface. The forms are rounded, and have numerous large, scattered, excurrent orifices. These lead into correspondingly large canals which intersect each other in the interior, and give the whole mass the appearance of being excavated or hollowed out. They are precisely similar to the Australian form, *Spongelia rectilinea*, but have a skeleton of finer texture, with less prominent and more numerous primary fibres.

Loc., Florida, in Mus. Comp. Zoology and in Soc. Coll., and La Paz, Lower California, in Soc. Coll.

Variety *foraminosa* Hyatt. The form and the surface of this variety are altogether peculiar. The sponge is, in reality, made up of an aggregation of large tubes radiating towards the circumference, and divided by tolerably thick walls. The regularity of the arrangement of these tubes and their increase in size outwardly, is the marked characteristic. The texture is of medium fineness, with nearly parallel, and quite closely set primary fibres in a specimen from Havana, in Coll. Mus. Comp. Zoology, in another, however, from Ft. Macon, in Yale Collection, the primary fibres are more widely separated, and the tissue is altogether looser. The secondary system of canals is also very well developed, and the interior therefore resembles that of the preceding varieties, though not so completely hollowed out.

Spongelia cana Hyatt.

This species has a remarkably white skeleton, although two of the three specimens examined evidently were not entirely free from animal matter; the exteriors are bleached very white. The general plan of the mass is similar to that of *Spongia Mauritiana*. Its resemblance to this last, in fact, is complete in form, aspect of the surface, and in the labyrinthine windings of the canals. The primary fibres are regularly distributed, and the secondary fibres connect them in a perfectly normal manner; the size of the fibres and the whole texture is as fine as that of any Spongelian yet observed.

Variety *cincta*. This is precisely similar in every respect, except that the whole exterior is covered by a thick layer of somewhat denser texture than the internal skeleton. This gives the surface a remarkably smooth aspect, covering up all the marked inequalities, and decreasing the size and number of excurrent orifices. The tissue of both varieties is similar to, but considerably finer than, that of *Spongelia excavata*, which they resemble more closely than any other species.

Loc., Noronha, Prov. Pernambuco, S. A., in Coll. Mus. Comp. Zoology.

Spongelia spinosa Hyatt.

The exterior of this species (Pl. XVI, fig. 33) is peculiarly rough or spinous, owing to the projecting points of the primary fibres, which extend considerably beyond the surface. The connecting tissue consists of a very irregular network of fibres. It is pierced by excurrent orifices, and occasionally marked by a channel. This tissue resembles that of *Spongelia incerta*. The absence of vertical tubes is also another similar characteristic;

the differences lie in the presence of continuous lines of primary fibres and the lesser density of the whole skeleton.

Loc., Mauritius, in Mus. Comp. Zoology, and in Soc. Coll.

Variety *rigida* Hyatt. This, after much hesitation, seems to be appropriately classified only when considered a distinct variety. The surface of the skeleton is covered by a thick growth of primary fibres. The general texture is finer than in *Spongelia dubia*, which it resembles closely, and the fibres smaller. It also still more closely resembles the typical variety of *spinosa*, but even here the texture is not exactly similar. The primary fibres are perfectly regular, and join the secondary fibres at right angles, and the projecting parts of the primary are never surrounded by any deflected secondary fibres, as in variety *spinosa*.

Loc., Beach at Ft. Pierce, Indian River, Fla., in Soc. Coll.

Variety *Codmani*. This variety was gathered by Mr. Codman at the Island of Teneriffe, and differs from the preceding only in the lightness of the skeleton, the smaller size of the fibres, and the irregularity of the form. The surface is also a trifle less spinous.

Spongelia Farlovii Hyatt.[1]

Variety *densa* Hyatt. One specimen (Pl. XVII, fig. 14) has a flabellate form from 10 to 15 mm. in thickness, and about 230 mm. in greatest breadth. The excurrent orifices are situated along the outer border in a single row. Each orifice in the specimen examined corresponded to a fistular swelling which rose like a ridge on the side. These ridges run together below, so that many of the excurrent canals are thus traceable throughout their larger ramifications. The structure is very dense, the surface smooth, the fibres small, and the mesh of the tissue exceedingly fine.

Loc., Phillip's Island, Australia, in Soc. Coll.

Variety *palmatiformis*. This variety has an aspect not unlike that of *Spongelia palmata*, owing to the thinness of the colony which permits the light to pass through quite freely. The primary fibres are, however, closely approximated, and besides the ordinary secondary fibres the peculiar open network of connecting tissue which distinguishes this species from *Spongelia rectilinea* is also present. This consists of a very fine net-like conjunction of threads finer than the secondary fibres, which connect the primary fibres sometimes horizontally and sometimes vertically. The incurrent orifices in both varieties are small and plentifully scattered over the surface, which has a peculiarly dense and smooth aspect on account of the prevalence of this connective tissue.

Spongelia rectilinea Hyatt.

Variety *irregularis*. One of the specimens examined (Pl. XVII, fig. 15*a*) is a sessile, but irregular mass, which may have been two complete branching colonies which have coalesced, or a very porous colony with a double base. The hollows running through the mass are so regular that they might have arisen in this unusual way, though it is more likely that they are the natural accompaniment of the growth of the mass. The principal characteristic is the smoothness of the surface of the skeleton and the distinctness of the primary fibres in the interior, which are loaded with pebble dust. The mesh is coarser than

[1] This species is respectfully dedicated to Prof. W. G. Farlow, to whom the author feels deeply indebted for the interest he has shown in this Memoir, and the important assistance he has given.

in *Spongelia Farlovii*, and the aspect of the surface rougher. The incurrent orifices are not specially distinguishable in the skeleton, owing to the fact that the connecting tissue does not so uniformly fill up the cells formed by the primary and secondary fibres. The excurrent orifices are about a line only in diameter, much smaller than in *Farlovii*, and irregularly peppered over the surface.

Loc., Phillip's Island, off Port Phillip's Head, Australia, in Soc. Coll.

Variety *tenuis*. One specimen (Pl. xv, fig. 13) has a slightly coarser skeletal texture than *irregularis*, and the form is regular and vase-shaped. The external surface is pitted and seamed by deep depressions. The internal surface is pierced by numerous excurrent orifices of small size. The primary fibres project but very slightly, and the whole is remarkably smooth. Another specimen of this variety existing in the Philadelphian collection has a similar form, but the outside of the cup is supplemented by two incomplete vase forms, budding from the base. Another specimen has a vase-shaped form, with a skeleton not quite so dense as in the first, but still very closely approximates to the same condition and surface, with precisely the same characteristics in the interior, where it was in perfect preservation.

Loc., Phillip's Island, Australia, in Soc. Coll., and near Sydney, New South Wales, in Acad. Nat. Sc., Philadelphia.

Variety *erecta*. This variety differs somewhat in the texture of the skeleton from *tenuis*. It is not quite so coarse, but it otherwise resembles it quite closely. The shape (Pl. xvii, figs. 12, 13) is quite distinct, being almost fistulose, and the exterior very deeply pitted. The inside of the cup is very shallow.

Loc., Phillip's Island, Australia, in Soc. Coll.

A specimen in the Collection of Peabody Academy from Swan River, Australia, is a tall, pedicellated, flabellate form, with numerous orifices on the upper edge. These, as in *Spongelia densa*, correspond to ridges which follow the directions of the internal channels. This form and these ridges give considerable similarity to *Spongelia densa*, but the skeletal structure is distinct, and like that described above.

Spongelia palmata Hyatt.

This species (Pl. xvii, fig. 15) is remarkable for the looseness and fineness of the skeletal structure. The form in the variety figured is flabellate, with a broad and very flat pedicle. The upper edge is, as usual, occupied by the excurrent orifices. There are ridges running from these and corresponding to the excurrent canals, but they are not very prominent. The texture is so loose that the light shines through all parts except the extreme lower part near the pedicle, where the tissue becomes very dense and hard. The primary fibres are not so coarse as in *Spongelia Farlovii*, but much more widely separated, and the connecting tissue of secondary fibres has a much larger and more irregular mesh. There is no appearance of net-like connecting fibres, and the tissue is so irregular that it is difficult to detect on the surface the usual polygonal cells of the genus.

Loc., Pacific Ocean, U. S. Ex. Exp., in Yale Coll.

Two other specimens, one in Coll. Acad. Nat. Sciences, Philadelphia, and one in the Society's Collection, agree with the description given above very closely, but there is a considerable variation in the surface. The largest is a foot broad by nine inches in height, and

the surface is pitted with shallow depressions or hollows about one half of an inch in diameter.

Loc., New South Wales, near Sydney.

Another form precisely intermediate in texture between these and variety *poculata*, also occurs in Coll. Acad. Nat. Sciences, Philadelphia, from Cuba. The form is a flattened cup-shape, with numerous depressions of similar flattened form on the sides; some of these are so deep that they are really smaller flattened cups, without, however, showing fistular orifices at the bottom of the depressions.

Variety *poculata*. This variety has a denser skeleton than the typical specimens of this species, but this is due to the closer approximation of the primary fibres, and not to any increase in the size, nor to any great change in the arrangement of the fibres. The form is fistulose, but the cup shallow above. The exterior is deeply folded, but otherwise the surface is smooth.

Loc., Phillip's Island, Australia, in Soc. Coll.

Variety *infima*. This variety is shown by one specimen, locality unknown, but probably New South Wales. It is in the Collection of the Academy of Natural Sciences of Philadelphia, and is a fragment composed of distinct branches more or less completely joined along their outer edges, forming a partially flabellate specimen. This is also very interesting, in so far as it probably shows one of the steps in the growth of the flabellate forms. It suggests the idea that these are primarily due to the lateral anchylosis of a certain number of branches growing in the same plane, but a more complete suite of specimens is necessary in order to test this view.

Spongelia enormis Hyatt.

This species can be distinguished by its peculiar surface and internal structure. The fibre is rather harsh and unyielding, but not wholly inelastic. The form is flattened, flabellate, manner of attachment uncertain. Excurrent apertures are all of small size, but very numerous and situated on the lateral ridges, not, as usual, in the channels. These lateral ridges are merely slightly raised above the surface, and about 3 mm. or so in breadth. They run in lines radiating from a central axis outwardly, and are ornamented by projecting bunches of fibres, in which, however, the single primary fibre at the centre is hardly so prominent as is usual in Spongelia. They, in fact, resemble those of Spongia, in which the primary fibre is often surrounded and concealed by a bundle of bent secondary fibres. In the interior, however, the singleness of the primary fibres may be easily determined, so that there can be but little doubt of the true affinities of the species. The primary fibres, however, are very crooked, and are consequently almost indistinguishable from the irregular network of secondary fibres. There is no apparent order of arrangement until the section is seen by transmitted light, then thick confused lines of radiating primary fibres appear. This aspect is enhanced by the sharp angle which the secondary fibres make at their junction with the primaries, their great number and close distribution.

The channels on the surface are shallow, very numerous, and about as wide as the ridges, and are not pierced by the larger apertures. In fact their existence, and those of the ridges, is probably entirely due to the peculiar linear arrangement of the small excurrent apertures and their accompanying tufts of fibres, which serve to elevate the surface in corresponding ridge lines, and leave the general surface of the sponge depressed. This is the only way to account for this otherwise exceptional structure, since in almost all cases

the channels of the surface in a sponge are essentially the product of the sub-epidermal horizontal canal system, and serve as lines of communication with the neighboring vertical canals.

Loc., Mauritius, in Coll. Mus. Comp. Zool.

Spongelia anceps Hyatt.

This form, of which I have only seen one specimen, is remarkably distinct from any species here described. It closely resembles *Spongelia Kirkii* in appearance, but differs in the aspect of the fibre, which is not so coarse, and the generally finer look of the skeleton. There is also no net-like connecting tissue as in *Kirkii*, and I separate them on this account. The cells, also, are very regularly formed, the primary fibres regular and single, and the secondary laid up between them in the most regular manner. It is the very type of a Spongelian.

Locality unknown; in Coll. Acad. Nat. Sciences, Philadelphia.

Spongelia ligneana Hyatt.

This species is allied to *Spongelia dubia* in general appearance, owing to the smooth aspect of the surface. It has, also, an exceedingly dense skeleton and a very small mesh between the fibres. The primary fibres project slightly above the surface in single points, and the whole is exceedingly hard and harsh to the touch. The fibres are very coarse, and the primary fibres very opaque, and also loaded with débris. A singular appearance is given to all the fibres by the abundant development of the concentric layers of keratode which surround the primitive cores. These last are quite transparent, so that under the microscope the effect is that of a hollow fibre, until the double outline or end view shows their solid character. The fibrous structure of the darker external part is also particularly noticeable.

Loc., Zorritos, Peru, in Yale Coll.

Spongelia Kirkii Hyatt.

Dysidea Kirkii? Bow., British Spong., Vol. I, p. 212.

The single specimen (Pl. XVII, fig. 19) examined possesses the coarsest skeleton of any species in this genus. The primary fibres are very thick, inelastic, and loaded with foreign matter. They project considerably beyond the surface, and the quantity of foreign matter in them gives them a peculiar whitish granular aspect. The connecting secondary fibres are a dark horn color and excessively large, especially in the older parts, such as the pedicle. They are also very widely separated, and more inelastic than the primary fibres. The result of this structure is an exceedingly open skeleton, through which you can see with ease, but which cannot be compressed in the slightest degree without breaking the fibres. The form is thick, erect, and irregularly flabellate, but the excurrent orifices are irregularly distributed on the top and sides, and, in fact, are hardly distinguishable at all upon the skeleton. The pedicle is thicker than the upper parts, and very much harder. In the lower parts of this pedicle the connecting tissue has become very dense, presenting quite a cellular aspect for considerable spaces, owing to the number of extra fibres secreted.

The resemblance to Dysidea in the skeleton is so close that only one characteristic separates it, the exclusion of the foreign matter from the secondary fibres.

Loc., Phillip's Island, Australia, in Society Coll.

Variety *Floridiensis*. Two specimens of dendritic forms exist in the Coll. Mus. Comp. Zoology, which can be referred only to this species. The fibres are not so much loaded with débris, but in other respects they resemble the oldest, densest and coarsest parts of the Australian form.

PHYLLOSPONGIADÆ.

This family contains sponges which, instead of growing up into solid heads, as is habitually the form of the Spongiadæ, are apt to form leaf-like or frondose stocks. These are more or less complicated in pattern, owing to the anastomosis of the fronds wherever they come in contact, and occasionally head-like colonies are thus produced. These, however, retain the frond, or leafy aspect, in the arrangement of the internal parts of the skeleton, as in *C. vermifera*. Many of the species are perforated, but this is a characteristic not yet understood, and therefore of doubtful value. The fibres of the skeleton usually radiate outwardly from one or both sides of a central mass or layer of fibres which have an irregular mesh without pronounced primary fibres. Fibres may be either very regular, as in Spongelia, or very irregular, or absent altogether. Otherwise they are precisely similar to those of the Spongiadæ, though not ordinarily so elastic. They differ from those of the Hircinidæ in these characteristics and in the absence of foreign matter from the secondary or connecting fibres.

Carteriospongia, gen. nov.[1]

The species which represent this genus are so remarkably different from all others that I have ventured to consider them as distinct. The form of the young in the species described is probably flabellate, but speedily becomes irregular, with numerous flabellate branches, which still farther complicate the aspect of the specimen by anastomosing among themselves. The aspect of the whole is thus rendered almost like that of a truly solid head, but on examination one sees the wide irregular cells between the network of flat branches and the leaf-like aspect of the branches themselves. The fibres are of medium size, like those of the Spongiæ, but are arranged externally like those of Spongelia, and with considerable regularity. *Spongia lamellosa* Esper may possibly belong to this genus. The microscopical structure is very similar in Ehler's preparation, and the external aspect of Esper's figure quite like that of *Carteriospongia perforata*, with the exception of the holes piercing the fronds.[2]

A difference in the mode of growth would ordinarily be of small taxonomic value, but one such as is described above, and in combination with peculiar skeletal characteristics, could hardly be associated in the same genus with the solid, or even branching heads of true Spongia or Spongelia. Phyllospongia alone approximates to this genus, and its true position may possibly be nearer to this remarkable group than our present information would lead us to suspect. This appears in *C. Madagascarensis*, which very closely resem-

[1] This genus is dedicated to Dr. H. J. Carter of the British Museum out of respect for his long continued and successful labors upon the natural history of the Poriferæ.

[2] The curious form, figured by Esper, and described as *Spongia penicillata*, is also an undoubted species of this genus. Loc., India.

bles Phyllospongia in its general aspect. On the other hand, an equally close approximation to true Spongia is to be observed in the softer and more pliable fronds of *C. perforata*, which might readily be mistaken for a true Spongian form.

Carteriospongia Otahitica Hyatt.

Spongia Otahitica Esper, Pflanz., 2, 270, pl. 44.
" " Ellis and Solander, pl. 59.

This curious species is singularly uniform in the aspect of the surface, and the specimens, all of which are from Zanzibar, have the leaf-like or palmate form. This seems rarely to be single; in most cases the leaves of neighboring colonies seem to anastomose, so that nearly every colony is supported by several stems. Both surfaces appear to be similar at first sight, but they are quite distinct. The outer side in perfect specimens is ribbed, like the inner, but the ribs, or longitudinal ridges, are thinner and longer than those on the inner or upper side. The latter have a more luxuriant growth and a more tufted aspect. Between these minute ridges the wall of fibres is thin, and pierced by rows of holes.

The primary fibres are in fascicles, and overloaded with débris. The mesh, where it can be seen, is regular, as in other species of this genus. The preparation of the fibres of the original of *Caccospongia lamellosa* Ehler has been compared, and shows great differences. The primary fibres are single and loaded with débris, but the mesh is quite similar to that which is usual in this genus, especially as regards its regular form and the thickness of the secondary fibres. These differences, though considerable, might occur in the same species, especially if one lived in clear waters, and the other in a place where there was much floating matter. It is very evident, however, that there are no holes through the fronds in *lamellosa*, and that the whole surface is not cut up by discontinuous ridges as it is in this form.

Loc., Zanzibar, in Soc. Coll., and in Peabody Academy, and Yale Coll.

Variety *aplanata*. This precisely resembles the preceding, but the ribs or ridges are depressed and thinner, and the surface is finely channelled.

Loc., Madagascar? in Soc. Coll.

Carteriospongia radiata Hyatt.

This species closely resembles *C. Otahitica* in general appearance and mode of growth, but is easily distinguished from it by the smoothness of the surface on both sides. The surface, also, instead of being evenly hirsute on the upper side, as in *C. mystica*, has a veil composed of minute fibres, which bridge over all inequalities of the interior, and conceal the longitudinal ridges which are formed internally. The primary fibres are single and pointed, but project slightly above the veil and are evenly distributed. Upon the lower or outer side no veil is found, and it differs from the upper or inner side in its loose texture, which allows the primary fibres to be seen, and in the figures made by the superficial canals. These radiate from a central, large pore, which represents the cloacal aperture, and form numerous star-like or dendritic figures in the surface of the skeleton. The interior is completely honeycombed by canals throughout the upper half of some leaves, while the lower part, the stems, and the younger sponges, are solid. Whether this is due to parasites or not, is uncertain. The microscopical structure is similar to that of *Sp. lamellosa* Esper, but the fibres are much larger. There is also a notable

absence of primary fibres in transverse and longitudinal sections, and the centre of the entire frond is apparently opaque with sedimentary matter. This opacity, however, is shown upon close examination to be largely due to the great irregularity of the mesh and the density and thickness of the fibres. From this denser centre the primary fibres radiate outwardly to either side; but even these are so tortuous that it is difficult to follow them.

Loc., Zanzibar, in Coll. Peabody Acad., Yale Coll., and Soc. Coll.

Variety *complexa*. This variety grows in clumps composed of small fronds resting on many stems, as in the Zanzibar specimens, but the radiating, surface canals are not formed as in the typical variety. The oscules are numerous and very small, and the canals radiating from them are equally minute, and are therefore hardly perceptible. Close observation, however, makes it apparent that the oscules have the same structure as in the typical form, and many of them show a decidedly stellate outline. In certain specimens the fronds are fewer and larger, and these lead into the next variety.

Variety *Dulsiana*. This form is easily separable, and may be readily distinguished from the preceding by the form and the absence of any large oscules. The latter are numerous on the veiled side, but are very minute, and never stellate. The veil, as in the case, also, of some specimens of variety *complexa*, may be present on both sides of the frond. The form rests upon a stem which branches above, dividing into numerous flattened fronds, which spread outward in the same plane. These broaden as they grow, so that the whole colony has precisely the aspect of the common dulse, *Rhodomenia palmata* Grev. The color of the skeleton is yellowish white.

Loc., Madagascar, in Soc. Coll.

Carteriospongia Madagascarensis Hyatt.

This variety, of which I possess only one specimen, is perfectly white, and the fibres transparent. The texture and the structure of the skeleton is closely similar to that of *C. lamellosa*, even to the manner of the arrangement of the primary fibres, and the way in which the débris is arranged, and it is also imperforate. It differs from the latter, however, in the absence of all pores, ridges, or marks of any kind, both surfaces being perfectly smooth; even the primary fibres do not project. There is also no veil, the mesh of the skeleton being about equally close and dense throughout. Here and there on the outer side, this dense aspect gives way to an exceedingly fine ribbed aspect, due to the arrangement of the internal skeleton in ridges with surface channels between them. On the inner side there are numerous small pores precisely similar to those of Phyllospongia, but the aspect of the internal structure of the skeleton is quite dissimilar, as is also that of the surface when examined with a magnifier. The form is similar to that of *C. perforata*.

Loc., Madagascar, in Soc. Coll.

Carteriospongia vermifera Hyatt.

This species is represented by only two specimens, and neither of these has the oldest part or base of the colony preserved, therefore it cannot be positively said that it was flabellate, though there is every indication that this was the case; the branches are all radiatory, as if derived from a small base. The anastomosing of the branches is more regular than in *Carteriospongia perforata*, and more complete, but there are no horizontal floors

between the branches. The branches, also, are solid, and have none of the perforations or ribs observed in *Carteriospongia perforata*, and are about one-twelfth of an inch in thickness. The fibres of the skeleton, however, appear to be of about the same degree of fineness in both, but the aspect of the surface in this species is very similar to a section of wood made through the burrows of the ship worm, whereas no such comparison can be made with *C. perforata*, the cells being much too irregular in size and shape.

Loc., Phillip's Island, Australia, in Soc. Coll.

Carteriospongia perforata Hyatt.

The single colony examined is a flabellate branch arising from a narrow base. This throws off other branches as it rises, which anastomose in a most irregular manner. They are ribbed longitudinally with branching, continuous ridges, between which are numerous round or elliptical openings, which penetrate to the opposite side. The branches are, in this specimen, about one-eighth of an inch in thickness.

Loc., Phillip's Island, Australia, in Soc. Coll.

Carteriospongia? mystica Hyatt.

The specimen upon which this species is founded, like all the Australian keratose sponges which have come under my observation, is of an exceedingly dark color, the ordinary red-brown. So distinct is this color and the hard woodeny aspect, that an observer can usually pick out specimens from this region without difficulty, though this rule has its exceptions, since there are always some among a large lot of West Indian specimens which are quite as dark colored internally, though perhaps never quite so deeply tinged on the exterior; whereas in Australian sponges the reverse is not infrequent, the internal parts of the skeleton being lighter colored than the exterior. The fronds in this specimen have combined into an irregular cup-shape with several supporting stems, so that it cannot be said whether the whole is from one frond, or the anastomosis of several neighboring fronds. The interior is perfectly smooth or rather even, for the primary fibres rise above the surface forming a pile or beard, which is quite perceptible without the magnifier. The pores are numerous, and there are no surface channels. These, and the cloacal ostioles, occur only on the exterior, a reversal of their customary distribution in this sub-order. This characteristic is also found in *Sp. lamellosa*, and in fact the enlarged portion of the outer surface, as figured by Esper, is very similar to the aspect of this sponge, except that the oscules usually lie at the point of junction of a group of more or less radiating canals. I am obliged to consider the determination of the genus as very doubtful; it may prove to be a true Spongian upon farther investigation, allied to, or identical with, *Sp. lignea*.

Loc., Adelaide Islands, So. Australia, in Yale Coll.

PHYLLOSPONGIA.

Phyllospongia papyracea Ehler.

Phyllospongia papyracea Ehler, Die Esper'sch. Spong. Erlangen, 1870, p. 30.

The peculiar form of the species (Pl. XVII, fig. 31), which alone represents this group, is unique. It is flat, like a leaf, and looks and feels like an extremely coarse, thick paper. The surface is dense, owing to the net-like anastomosis of the finer intermediate fibres of

the skeleton, and the accumulation of foreign materials, fine particles of sand, foraminiferæ and broken spicules, etc. When held up between the observer and the light, numerous small canals radiating and branching from the base reticulate the interior. These are penetrated by numerous closely adjoined incurrent pores. The excurrent pores are all on the upper side and of various sizes, though none very large. The accumulation of foreign matter is also much less on the lower side, so that the reticulated aspect of the surface can be observed. The longitudinal threads are radiatory, but are irregular in size and shape, and loaded with spicules and foreign material.

The connecting or secondary set of fibres are not placed at right angles to the primary, but are very irregular. They do not differ greatly in size, and are so slightly colored as to be almost perfectly diaphanous when mounted in balsam. They are also nearly completely free from foreign matter. Besides these, there is still another system of extremely minute fibres connecting both of the former irregularly with a fine network similar to that found in Stelospongos, but differing in its want of regularity and the manner in which it permeates the whole structure. These characteristics are wholly Spongian, and do not seem to confirm Ehler's conclusion that it is a form closely allied to Chalina, though they justify his description of the form as a distinct genus. Ehler considers that Esper's *Sp. plicata* shows considerable affinity for this group in its characteristics, but of this I have never seen an example, or even Esper's figure.

Loc., Cape of Good Hope, in Ward's Museum and in Soc. Coll.

HIRCINIADÆ.

The great contrast presented by the aspect of the skeleton in this family as compared with that of either the Spongiadæ or Phyllospongiadæ, would justify a separation independently of more minute structural differences. There is not that distinction between primary and secondary fibres which is to be found in the two preceding families. When débris is present in the water the fragments, which must have been derived from the dermis, are not confined to the core of the primary fibres alone, but are equally prevalent in the secondary fibres, showing that they must have been formed by the same layer of the dermis as the primary fibres. Both classes of fibres, also, are sarcodous or gelatinous, and are readily dissolved in some specimens by maceration in cold water. They are also flatter in form, and have a fibrous aspect when dried, in some species due probably to this flattening.

Dysidea approximates most closely in the color and aspect of the fibres to those of Spongia, but can never be mistaken for a true Spongian, though the fibres evidently possess more keratode than those of any other species in the family. The forms of the specimens are similar to those prevalent among the Spongiadæ, dendritic, solid, flabellate, fistular and cup-shaped, but never frondose, as in the Phyllospongiadæ.

Dysidea Johnst.

Spongelia (pars) Schmidt and Bowerbank.

The skeleton in this genus, as in the single species which appears to represent it in Florida, appears to combine the characteristics of several genera. The primary fibres are large and sometimes partially compound, as in some species of Stelospongos; the secondary fibres partly like those of Spongelia and partly like those of Hircinia. Not only are the primary fibres loaded with foreign material, as in Spongelia, but the secondary, also, and

besides this the membranes everywhere, and the internal portions of the sarcode. This characteristic therefore has greater significance than in any other species, and justified the retention of the distinct generic name of Dysidea.

Dysidea fragilis Johnst.

Dysidea fragilis Johnst., Brit. Spon., p. 286.

Dysidea fragilis Bow., Brit. Spong., p. 381. pl. 13, 14.

This species (Pl. XVII, fig. 17) resembles Johnston's *Dysidea fragilis*, but evidently has a much coarser mesh, and probably grows larger. Its color when living is not known. Otherwise the specimen corresponds quite closely to the descriptions of Johnston. The skeleton (Pl. XVII, fig. 18) is similar to that of Spongelia, but presents characteristics which ally it closely with Hircinia. There is a tendency to branch in the primary fibres, and they are often compound. The secondary fibres are sometimes single and hairy, and sometimes composed of the usual mass of cellular or perforated fibres as in Hircinia. The membranes are loaded with foreign materials, and so also are the primary and secondary fibres, with the exception of the single dark horn-colored ones alluded to above. The surface is rather rough, with the slightly projecting points of the primary fibres covered with hardened sarcode. The whole mass when dried is very light and porous, and of a flat, tabulate shape. The excurrent orifices are few and rather small. When carelessly dried these entirely disappear, and the specimens become very hard.

Loc., Zanzibar, in Coll. Peabody Academy; Biscayne Bay, in Soc. Coll. Specimens in the Coll. Mus. Comp. Zool. are named Spongelia? by Schmidt.

Hircinia Nardo.

Filifera Lieb.

Sarcotragus Schmidt.

Polytherses Duch. et Mich.

This genus is peculiarly liable to the attacks of a seeming parasite, which forms a filamentous tissue often connecting all the fibres of the sponge with a sheet-like net-work. The filaments disappear in a completely macerated sponge, or if present, present a hollow tubular aspect with a bulb at one end, as figured by Schmidt. In less completely macerated specimens the contents are visible in the interior of the threads, and are broken up, looking in some specimens like cells. This may be erroneous, but certainly these threads are not constituted like regular sponge fibres, and are probably parasites of some sort, but whether Algæ or not, it is difficult to determine.

Carter describes it as an Alga, under the name of *Spongiophaga communis*, and says that he has found it in other sponges than Hircinidæ. Neither Schmidt nor others have, however, quoted any similar instances, nor has Carter given the names of the other species. Schmidt is evidently very doubtful, but is inclined to the same view as Kölliker, that the filaments are distinct elements from the fibres, and this is also my own impression. The filaments are much larger than the fibrillæ, the color and aspect when dried distinct, and the former never have the little bag on the end.

Dr. W. G. Farlow, the well known Algologist, has had dried specimens under examination, and reports to me that he finds no sure grounds for referring them to Algæ, or any plant structure, and examinations of the living sponge will probably be necessary in order to determine the exact nature of these threads. The extremely thin, sheet-like arrangement of the fibrillæ of the connecting fibres in many species adds to the difficulty of separating the filaments from the fibrillæ.

The fibres are composed of fibrillæ, or threads of horny-colored appearance. These are bound together in bundles to form the primary or vertical fibres, and are more or less spreading, or fan-like, especially at their bases; when modified by the connecting tissue, the horizontal fibres sometimes spread into complete screens, even when entirely freed from the parasitic filaments. Both systems of fibres are usually loaded with foreign matter, and often this is so purely composed of spicules as to lead to curious blunders. Duchassaing and Michellotti's reference of this genus to the siliceous sponges is due to this, and I have seen one specimen inseparable from a true Chalina, either in the form or arrangement of the spicules. The epidermis is remarkably thick, and usually loaded with foreign matter, but when partly free from this, or partially macerated, exhibits certain peculiarities. The skin entirely covers the points of the primary fibres as a rule, but when they protrude it is seen that they are often composed of several fibres, or bundles of fibrillæ. From the terminations of these there spreads out an extensive epidermal network of secondary fibres, the close association of which with this external membrane explains the load of foreign matter which they bear.

Hircinia campana Nardo, Isis. 1833-34.

Spongia campana Lamarck, Anim. sans. Vert., 2d ed., vol. 2, p. 364.

Filifera campana Schmidt, Spong. d. Atlant. Gebietes, p. 30.

Polytherses campana Duch. et Mich., Op. cit., p. 68.

Variety *typica*. The normal variety of this species is vasiform (Pl. xv, fig. 19). It may be either ribbed externally, or smooth, with of course the exception of the projecting spines composed of the bundles of vertical, primary fibres.

Variety *fixa* Duch. et Mich. This is the same as *typica*, but the vase is open on one side (Pl. xvii, fig. 28). I have examined complete series of this and of the normal variety, and though they are distinct forms, there are many intermediate forms, and one specimen has one side open below, showing that it began life as variety *fixa* and ended it as one of the normal variety. One specimen of this variety in Mus. Comp. Zoology, is reported from 40 fathoms off Conch Reef, Fla.

Some specimens of both of these varieties have peculiar outgrowths of certain parts. These may take place externally and surround the cup with a hedge of branches, or within, giving rise to single projecting branches of greater or less length. Again this tendency to branch may be accompanied by a thickening of the walls, which if carried out fully would entirely change the hollow vase to a mass with many radiating or erect branches at the top. In all of these varieties the larger apertures are within, and the smaller without.

Variety *felix*.

Polytherses felix Duch. et Mich.

This variety is similar to the young of the last described before it begins to assume the vase form. It is short and clumpy, with orifices on the upper side, which may either be numerous, or single. The bundles of fibres project above the surface more than in

campana, and are decidedly larger. Those that have only one or two orifices are really fistular, but lead into solid forms with projecting orifices. They may be single, or multiple to such an extent as to form large masses, and they may also be truncated, or furnished with projecting excurrent tubes. The branches springing from the typical vase-form are flattened, and they precisely resemble the flabellate forms in structure and aspect. These may be either as described by Duch. et Mich. in their "Spong. de la Mer Caraibe" branched above like *P. armata*, or with an entire border, as in *P. tristis*, *ignobilis* and *linguiformis*, or with a semicircular form and a line of orifices above, as in *P. marginalis*.

The modifications of form, in fact, seem almost endless, including also those like *P. columnaris* (Pl. xv, fig. 17) and *P. cylindrica* Duch. et Mich., which are composed of stout branches. There are also numerous variations of all these, and some colonies which may be considered amorphous (Pl. xv, fig. 18), in so far as they appear to be composed of branches irregularly soldered together, and having several points of attachment. The extent and accidental character of the variation make them exceedingly difficult to classify, and I have not been able to distinguish some of them in a satisfactory manner. These variations are not confined to the form, but extend also to the skeletal tissue, which may be either excessively coarse and open, with a rough surface and large spines, or quite fine and close in structure, with smoother surface and very slight spinous projections. The sunken interspaces between the spinous projections may be from 2 mm. to 10 mm. in diameter. The general size is about 4 or 5 mm. According to Dr. Palmer, this species is not difficult to dry, and retains its form on account of the density and comparative elasticity of the skeleton. The interior in alcoholic specimens is usually very porous and open, owing to the numerous canals and slight development of the mesoderm, but in some specimens quite a fleshy aspect is assumed, though the mesoderm is never very solid. Color when living is black, when dry reddish brown, or white.

Loc., Nassau, Key West, Biscayne Bay, in Soc. Col.; Havana, in Mus. Comp. Zool. Coll. Habitat, reef in 4–10 ft. of water for the normal variety. Whether the other varieties also occur in the same depth of water, was not stated by Dr. Palmer.

Besides the above, there exists in the Coll. Acad. Nat. Sciences of Philadelphia a remarkable variety. There are two specimens, the tallest about three inches, of slender, irregular, branch-like forms, but consisting each of a perfectly fistular tube with very thick walls. This appears to complete the remarkable cycle of varietal forms, which are represented in this species, and which might very reasonably be described as many distinct species, on account of the extraordinary characteristics found in the skeleton, which often differs in texture as much as the varieties differ in form. I have not, however, succeeded in finding any constancy in the skeleton of any special form, or series of forms, the texture appearing to be independent of the form. A thick lump-like form of this or a closely allied species, has also been collected at La Paz, Lower California, and presented to the Society by Mr. W. G. W. Harford, and two specimens have been received from the Peabody Academy, Salem, from Zanzibar, which do not seem to differ from the ordinary type of the skeleton, except in the quantity of contained sediment, this being less than is usual in Florida specimens. Mr. Goode also sends nearly all the described varieties from Bermuda, so that it would appear to be cosmopolitan in distribution.

Hircinia arbusculum Schm. (Mss.)

I find a specimen in the Museum of Comparative Zoology, named by Schmidt *Hircinia arbusculum*. It seems to be a good species, and therefore I adopt the name, although I can find no corresponding description, or even mention of the specimen in Schmidt's works. The half dozen specimens examined were all from Kingsmills Islands. They are composed of irregular, somewhat flattened and constantly anastomosing branches. The surface is finer and smoother than is customary in *Hircinia campana* in the most extreme variations. The skeleton corresponds to the surface, and is also extremely fine, as compared with the last mentioned species. The color of the dried specimens is light, as in *H. campana*, but the parasitic alga was not present in the single specimens examined with the microscope.

Hircinia acuta Hyatt.

Polytherses aeuta Duch. et Mich., Spong. de la Mer Caraibe, Verhand. Maatsch. et Wetensch., Haarlem, 1864, 21–2, p. 72, pl. 13.

This form (Pl. xv, fig. 20) is distinguishable from others by the large size of the projecting fibres, the thick, tough skin covering them, and the large size of the spaces between the spinous projections. The form of the specimens examined was rotund, the top alone occupied by the numerous excurrent orifices, which were gathered together in one or two sieve-like patches. The sunken spaces between the spines are from 5 to 15 mm., or even 20 mm. in diameter.

This is one of the so-called Logger-Head Sponges, and emits during the process of maceration or drying an almost unbearable stench. The largest seen, according to Dr. Palmer, was about four feet in diameter and one foot high. The fibres are not at all elastic, and so loosely interwoven that when artificially macerated, the skeleton will entirely melt away if not closely watched and delicately handled. The specimen figured, Pl. 17, fig. 26, could have been all washed away by pressure, so soft were the fibres after forty-eight hours' immersion. When being dried they must be constantly turned, or they will soften, looking like melted rubber, according to Palmer, and lose entirely their normal form. Color when living, according to the same observer, very dark gray externally, and black internally. The dried specimens become much lighter, a dark drab of a purplish shade. Internally this sponge is remarkable for the large size and number of the canals, which are not indicated upon the surface, and which render the whole structure very light. Habitat, reef, in 8 feet of water.

Loc., Nassau, in Soc. Coll.

Variety *filamenta*. These specimens I at first supposed to be distinct, but after the maceration of one specimen of *H. acuta* I was struck by the close resemblance of the skeletons. The three dried specimens examined have a very open structure, but the skeleton is so completely covered by the filamentous tissue that it is hardly possible to see any part of it distinctly. The interior is exceeding hollow, or rather cellular, the hollows being separated by thin walls of the filamentous tissue, within which lie the fibres of the true horny skeleton. These skeletons are therefore of the most paper-like structure and extreme porosity. The primary fibres project in large tufts beyond the surface.

Loc., Cape Florida, in Soc. Coll.

Variety *nigra*. This form (Pl. xv, fig. 21) is apparently intermediate between *Hircinia acuta* and the solid varieties of *Hircinia campana*. The exterior has considerable resemblance to the varieties of the latter with a coarse surface, but the structure is more papery, the spinous projections readily yielding to the touch even in the most carefully dried specimens. These spinous projections are also shorter than in *H. campana*, and much smaller than in *H. acuta*. The epidermis is more destructible than it is usually in *H. campana*, and therefore very distinct from the coarse persistent epidermis of *H. acuta*. The skeleton, however, has the same open structure and want of elasticity also observed in *H. acuta*, so that, as stated by Dr. Palmer, the greatest care must be taken in drying in order to preserve the form. The shape is the same as in *H. acuta*, and the arrangement of the excurrent apertures similar, but less sieve-like. The interior, also, is cavernous, as in that species and in *H. filamenta*. The filamentous tissue is present, but not so abundant as in *H. acuta* or *filamenta*, and much more easily removed by maceration. Color in the living sponge black, in the dried form black to dark gray. Habitat, reef.

Loc., Biscayne Bay, in Soc. Coll., and Florida, in Mus. of Comp. Zoology.

Variety *longispina*.

Polytherses longispina Duch. et Mich., Op. cit, p. 71.

This form, of which I have seen but one specimen, is readily distinguished by the structure of the bundles of primary fibres. These are cylindrical bundles constructed, as in Stelospongos, of long primary fibres united by a secondary and rather closely set system of transverse fibres. In fact, so strong is the resemblance that it was at first classified with that genus. The intimate study of the fibres themselves, however, show that they belong to the Hircinian type, especially the broad membranous junction of the secondary with the primary fibres and their color. The intermediate filamentous tissue is also present, and helps to identify the species as a Hircinian form.

Loc., Havana, in Coll. Mus. Comp. Zoology.

Hircinia cartilaginea Hyatt.

Spongia cartilaginea Esper, Pflanzenthiere, vol. 3, pl. 64.

This form may be at once distinguished by the peculiar structure of the skeleton. The primary fibres broaden out before branching into exceedingly flat, flabellate fibres from one to three mm. broad. The branches then appear separated by a vesicular tissue of secondary fibres, the meshes of which are at first, when in the crotches of the branches, very round and minute, but gradually enlarge, and finally stretch from branch to branch of the fibre in the usual form. This of course is a characteristic of great variability, and often in the same specimen the observer finds quite an open tissue in some parts, and in others an almost closed network, and in some cases a continuous shelf stretched vertically between the vertical branches. The five specimens examined were completely macerated, and this may account for the absence of filamentous tissue.

Loc., Key West, in Soc. Coll., and Florida, Havana, in Coll. Mus. Comp. Zoology.

Variety *horrida*. One of the specimens examined is a bi-fistural form (Pl. xvii, fig. 29) with a skeleton partly of a curious pinkish hue, due to the bright colored foreign matter, fragments of Corallines, taken into the fibres from the epidermis. The mesh in the interior is exceedingly regular, consisting of broad, upright primary fibres, bound together by secondary fibres of a similar broad, flattened form, these again united by a vertical set of

short fibres, rendering the intermediate tissue vesicular. The primary fibres are all single, and generally colored a darker shade than the secondary fibres, which are often quite white. They project considerably as sharp, single spines, above the surface. The maceration of this specimen was very complete, the whole of the interior being encrusted with coral sand.

Loc., Cape Florida, in Soc. Coll.

Another specimen from Havana, in Coll Mus. Comp. Zoology, is intermediate in the character of the skeleton between the last and true "*cartilaginea*." In some parts of this the broad flabellate aspect of the primary fibres obtain, and they are arranged in lines, or ridge-like projections on the surface; whereas in other parts the primary fibres are single and with connecting tissue form regular, four, five or six sided cells, as in the Cape Florida specimen. The observer needs to be on his guard in the examination of this species, since in some specimens the spicules taken into the cores of the fibres, both primary and secondary are all of one kind and quite whole, except here and there where they have been bent too suddenly.

Hircinia purpurea Hyatt.

Spongia rubens Duch. et Mich., Op. cit., pl. x, fig. 1.

This species is not the *Spongia rubens* as figured by Esper or described by Schmidt as *Pachychalina rubens*, but is unquestionably identical with the species described by Duch. et Mich. The specimens I have seen are all possessed of simple cylindrical branches, reminding one decidedly of the ordinary *Chalinula oculata* of this coast, both in form and in the aspect of the surface. This impression can only be dissipated by the minute examination of the skeleton. The fibres resemble those of *H. cartilaginea* in their flatness, the aspect of the horny matter which is essentially fibrous, the concentric arrangement of the fibres being in many cases hardly distinguishable. There is a peculiar irregularity in the shape of the fibre, due to the ridges formed in the centre by the greater shrinkage of the sides. The primary fibres are arranged symmetrically in a radiatory manner and somewhat widely separated; the secondary fibres are at right angles and connected by a horizontal series of fibres, which on the surface form a ditellian veil of a rather loose texture.

Dr. Palmer reports this sponge as habitually growing upon other sponges, corals or gorgoniæ, and as quite uniform in its aspect. It dries readily, and the skeletons, even in specimens dried without being macerated, permit the light to pass through them, as in *Chalinula oculata*. The color when living is purple.

Loc., Florida and Nassau, in Soc. Coll.; Pacific Ocean, U. S. Ex. Exp., in Coll. Acad. Nat. Sciences, Philadelphia.

CERATELLADÆ.

Dr. Gray describes this family in the Proc. Zool. Society of London, in the volume for 1868, from two specimens which he respectively refers to two genera, Dehitella and Ceratella. They are certainly very remarkable sponges, and undoubtedly, in spite of their form and the extreme regularity of their skeletal structure, must be placed in the suborder of the Spongiæ. The fibres are solid, and contain no foreign matter, or spicules. The fibres are large in proportion to the size of the stems, and very closely united, so that it is difficult to distinguish them into primary, or vertical and secondary, or horizontal

connecting fibres. In fact, the structure, as stated by Gray, resembles quite closely that of the internal vesicular walls of porites, but is hardly so irregular. If, for instance, a stem be cut in section and viewed with the microscope, the vesicular openings arrange themselves in circles almost as regular as those in the spines of some Echinoderms. The primary fibres sometimes run together into a small, broad fibre, and these radiate from the centre.

Gray's discussion of the affinities of the two specimens betrays considerable doubt of the affinities of these sponges, and he appears to refer them to sponges as a provisional measure. There can be no doubt, however, that the structure of the skeleton of the apertures, with their irregular, internal, vesicular partitions, and the whole aspect, including the surface, which is striated with short, sinuous channels, has nothing coral-like in it; on the contrary, the whole is thoroughly sponge-like.

Ceratella Gray.

Dehitella Gray.

The distinctions described by Gray between these groups are barely specific in importance, and certainly not generic. The species or form described below combines the characteristics of both genera. Some branches have the projecting spines and oscules only on the sides (Ceratella), while others have them all around the surface of the stem (Dehitella).

Ceratella labyrinthica Hyatt.

A single specimen from the Mauritius occurs in the Coll. of the Museum of Comp. Zoology. The base is solid, without oscula, much compressed, and smooth, in height about 50 mm., in breadth 38 mm., in thickness only 3 mm. From this flabellate base spring three equally compressed main branches, which give rise to several smaller branchlets and twigs. Of course as the size diminishes the branches are rounder, since the thickness remains about the same throughout. The youngest twigs are frequently, therefore, quadrate, with nearly equal sides. The oscula are on the sides of the larger branches, but are distributed on all sides of the branchlets and twigs. The spinous-like processes are confined, however, to the sides in nearly all cases, there being but few exceptions even on the twigs. These are not, as described by Gray, spines composed of primary fibres, but sharp elevations of the skeleton on the lower side of each osculum. The front and back of the branches and base are smooth, and under the magnifying glass have a close vesicular aspect. The color is a dark yellowish brown. A fine specimen also occurs from Cape of Good Hope, in Prof. Ward's collection, at Rochester, from which Fig. 30, Pl. XVII was taken.

Note. Two specimens, Pl. XV, figs. 22, 23, were introduced into the plates under the impression that they were species of Spongelia, but the microscopical examination of the skeleton showed them to be spicular. Subsequently I found a specimen identical in every respect with Fig. 22, which, however, had fibres free from spicules, and a new examination of the originals of Figures 22, 23 was made, disclosing the fact, that the perfect imitation of Chalina presented in my first preparation was accidental. This in its turn led me to make renewed researches among the species of Tuba, and I now begin to think that I may be obliged to withdraw from the position taken in the first part of this paper, and admit Tuba as a genus of Sponginæ. It is very remarkable that there should be any doubt on such a point; but although I have examined more than fifty microscopical sections of different species of Tuba, sometimes several preparations to a species, I cannot make up my mind as yet whether the spicules are indigenous or foreign.

Explanation of Plate xv.

SPONGIA.[1]

Fig. 1. *S. officinalis*, sub-species *tubulifera*, var. *rotunda*. Loc., Nassau. See p. 513.
2. *S. graminea*. Loc., Key West. p. 516.
3. *S. discus*. Loc., Nassau. p. 514.
4. *S. equina*, sub-species *gossypina*, var. *alba*. Loc., Nassau. p. 519.
5. *S.* " " " var. *barbara*. Loc., Cape Florida. p. 519.
6. *S. agaricina*, sub-species *dura*, var. *typica*. Loc., Nassau. p. 522.
7. *S. equina*, sub-species *cerebriformis*, var. *typica*. Loc., Key West. p. 520.
8. *S.* " " " var. *plana*. Loc., Key West. p. 520.
9. *S.* " " " var. *caliciformis*. Loc., Key West. p. 521.
10. *S. agaricina*, sub-species *corlosia*, var. *elongata*. p. 524.
11. *S.* " " " var. *fusca*. p. 524.
12. *S. lapidescens*, var. *turrita*. Loc., Bermuda. p. 527.

SPONGELIA.

Fig. 13. *S. rectilinea*, var. *tenuis*. Loc., Australia. p. 537.

STELOSPONGOS.

Fig. 14. *S. cribriformis*, var. *typica*. Loc., Havana. p. 531.
15. *S.* " var. *stabilis*. Loc., Pacific Ocean. Yale Museum. p. 531.
16. *S. levis*. Loc., Pacific Ocean. Yale Museum. p. 530.

HIRCINIA.

Fig. 17. *H. campana*. var. *columnaris*. Loc., Key West. p. 547.
18. *H.* " var. ——— " " p. 547.
19. *H.* " var. *typica*. " " p. 546.
20. *H. acuta*. Loc., Nassau. p. 548.
21. *H.* " var. *nigra*. Loc., Biscayne Bay. p. 549.

TUBA.

Fig. 22. *T. compacta*. Loc., Cape Good Hope. Ward's Coll. p. 551, note.
23. *T. confusa*. " " " " p. 551, note.

Explanation of Plate xvi.

SPONGIA.

Fig. 1. *S. equina*, sub-species *gossypina*. This shows a piece cut out of the side of an aged specimen. p. 517.
2. *S.* " " *meandriniformis*. Loc., —— p. 519.
3. *S.* " " *gossypina* var. *solitaria*. Loc., —— p. 519.
4. *S.* " " " var. *hirsuta*. Loc., Nassau. p. 519.
5. *S.* " " " var. *porosa*. " " p. 518.
6. *S.* " " " var. *dendritica* " " p. 518.
7. *S.* " " " fistulose var. of *alba*. Loc., Bahama. p. 519.
8. *S.* " coarse Mediterranean variety. p. 517.
9. *S.* " Gerbis variety. p. 517.

[1] All the specimens figured are reduced to about one-fourth of the diameter of the original size.

Fig. 10. *S. officinalis*, sub-species *tubulifera*, var. *solida*. Loc., Nassau. p. 514.
11–11*a*. *S.* " " " var. *pertusa*. " p. 512.
12. *S.* " " " var. *mollis*. " p. 513.
13. *S.* " " " var. *exotica*. " p. 514.
14. *S.* " " " var. *corlosiformis*. " p. 513.
15. *S.* " " " var. *rotunda*. " p. 513.
16. *S.* " " " piece of an aged specimen. Loc., Nassau. p. 509.
17. *S.* " " " var. *prava*. Loc., Nassau. p. 513.
18–19. *S.* " " *Mediterranea* var. *Adriatica*. Loc., Mediterranean. p. 511.
20. *S.* " " var. *tubuliformis*. " p. 511.
21. *S.* " " var. *mollissima*. " p. 511.
22. *S. agaricina*, sub-species *Zimocca*, var. with irregular form. Loc., Mediterranean. p. 522.
23. *S.* " " *punctata*. Loc., Nassau. p. 523.
24–25. *S.* " " *dura*, var. *typica*. Loc., Nassau. p. 522.
26. *S.* " " *corlosia*, var. *gossypiniformis*. Loc., Nassau. p. 524.
27. *S.* " " *punctata*, var. *densa*. Loc., Nassau. p. 523.
28. *S. equina*, " *cerebriformis*, var. *Mexicana*. Loc., Vera Cruz. p. 521.
29. *S.* " " " var. *obscura*. Loc., Nassau. p. 521.
30. *S.* " " " var. *caliciformis*. Loc., Nassau. p. 521.
31. *S. agaricina*, sub-species *corlosia*, var. *fusca*. p. 524.

SPONGELIA.

Fig. 32. *S. incerta*. Loc., Phillip's Island, Australia. p. 533.
33. *S. spinosa*. Loc., Mauritius. p. 535.

Explanation of Plate xvii.

SPONGIA.

Fig. 1. *S. agaricina*, sub-species *corlosia*, var. *elongata*. Loc. Biscayne Bay. p. 525.
2. *S. vermiculata*, var. *negligens*. Loc., Nassau. p. 526.
3. *S. lapidescens*, var. *typica*. Loc., Havana. p. 527.
4. *S. vermiculata*, var. *negligens*. Loc., Key West. p. 526.
5. *S. lapidescens*, sub-species *Mauritiana*. Loc., Mauritius. p. 528.
6–7. *S.* " " *dentata*. Loc., Havana. p. 528.

SPONGELIA.

Fig. 8. *Sp. velata*. Loc., Zanzibar. p. 534.
9. *S. dubia*. Loc. Nassau. p. 534.
10–11. *S.* " var. *excavata*. Loc., Cape Florida. p. 535.
12–13. *S. rectilinea*, var. *erecta*. Loc., Phillip's Island, Australia. p. 537.
14. *S. Farlovii*, var. *densa*. " " p. 536.
15. *S. palmata*. Loc., Pacific. Yale Museum. p. 537.
15*a*. *S. rectilinea*, var. *irregularis*. Loc., Phillip's Island, Australia. p. 536.

DYSIDEA.

Fig. 17. *D. fragilis*. Loc., Biscayne Bay, Fla. p. 545.
18. *D.* " Loc., Indian River, Fla. p. 545.

SPONGELIA.

Fig. 19. *S. Kirkii*. Loc., Phillip's Island, Australia. p. 539.

STELOSPONGOS.

Fig. 20. *S. Pikei.* Loc., Mauritius. p. 532.
21. *S. Maynardi.* Loc., Key West. p. 529.
22. *S.* " Loc., unknown. p. 530.
23–24. *S. lævis* var. *rotundus.* Loc., Phillip's Island, Australia. p. 530.
25. *S. cribriformis*, var. *stabilis.* Loc., Pacific. Yale Museum. p. 531.

HIRCINIA.

Fig. 26. *H. acuta.* Fragment of a macerated skeleton. Loc., Nassau. p. 548.
27. *H.* " var. *filamenta.* Loc., Cape Florida. p. 548.
28. *H. campana*, var. *fixa.* Loc., Cape Florida. p. 546.
29. *H. cartilagina*, var. *horrida.* Loc., Cape Florida. p. 549.

CERATELLA.

Fig. 30. *C. labyrinthica.* Loc., Cape of Good Hope. Ward's Coll. p. 551.

PHYLLOSPONGIA.

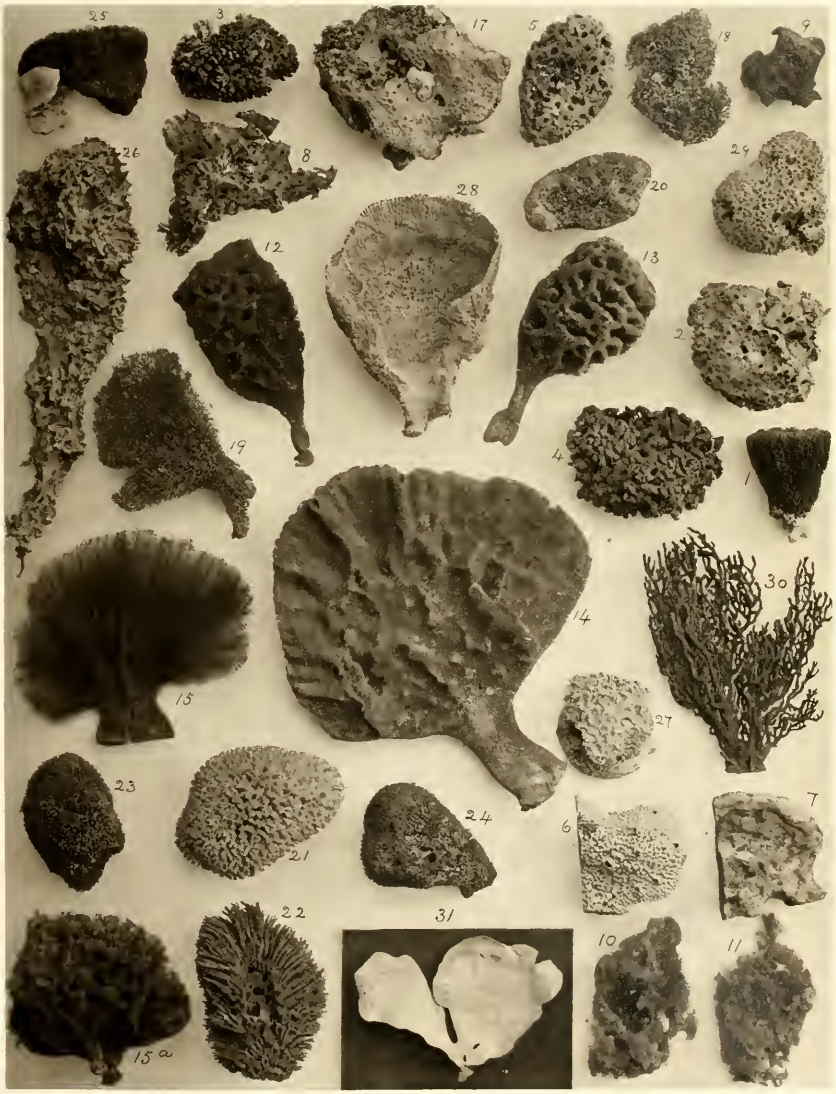
Fig. 31. *P. papyracea.* Loc., Cape of Good Hope. Ward's Coll. p. 543.

ALLEN & ROWELL, ARTIST'N PHOTO.

A. HYATT, ON THE SUB-ORDER SPONGINÆ.

ALLEN & ROWELL, CARBON PHOTO.

A. HYATT, ON THE SUB-ORDER SPONGINÆ.



ALLEN & ROWELL, LARSON PHOT.

A. HYATT, ON THE SUB-ORDER SPONGINÆ.

XIX. Prodrome of a Monograph of the Tabanidæ of the United States.

Supplement.

By C. R. Osten Sacken.

Read November 15, 1876.

Since the publication of the second part of this Prodrome, I have obtained some materials which enable me to complete and, in some respects, to correct, the descriptions of the North American species of the genus *Tabanus*.

To the fifty-four species already described by me, I add three, one of Say's species (*T. annulatus*) which I did not possess before; another, which I took at first for a possible variety of *Tab. abdominalis*, and which I recognize now as a separate species (*T. exul*); the third seems to be new. The species which I brought from California I reserve for another publication.[1] I also give descriptions of the males of *Tabanus fuscopunctatus* and *rufus*, which were not known before, and were recently obtained by Mr. H. K. Morrison; and, finally, I complete the descriptions of *T. longus* and *Wiedemanni*.

A considerable proportion of my new material I owe to Mr. Geo. Dimmock, who collected a large number of *Tabani* at Cumberland Gap, Kentucky, in July, 1876. The list of these *Tabani*, with the number of specimens taken, is an interesting datum towards the knowledge of the geographical distribution of the genus: — 1. *T. longus*, 50 specimens; 2. *atratus*, common; 3. *americanus*, not rare; 4. *fulculus*, numerous specimens; 5. *abdominalis*, 16 specimens; 6. *exul* n. sp., 9 sp.; 7. *giganteus*, 4 sp.; 8. *lineola*, 6 sp.; 9. *melanocerus*, 2 sp.; 10. *molestus*, 7 sp.; 11. *coffeatus*, 6 sp.; 12. *costatus*, 2 sp.; 13. *nigrescens*, 3 sp.; 14. *Wiedemanni*, 2 sp.; 15. *vivax*, ♀ (?), 2 sp.; 16. *annulatus*, 1 sp.

As the three species described here for the first time are not contained in the analytical table of the species (*ante* p. 427), I prefix short diagnoses to the descriptions, in order to facilitate their recognition. When the time comes to draw up a new analytical table of the N. A. Tabani, it will be found more convenient, I think, to divide it in two parts; one for the Northern and Middle States, and a separate one for the Southern States.

The name of my *Tab. socius* (p. 467) must be changed, as there is an earlier *T. socius* by Walker. I will call it *T. epistates*.

Tabanus annulatus.

Tabanus annulatus Say, Journ. Acad. Phil., III, 32, 2; Wiedemann, Auss. Zw., I, p. 185, 111.

Female. Eyes glabrous; frontal callosity unusually small; thorax whitish pruinose; abdomen brown, hind margins of segments whitish pruinose and beset with white hairs; wings immaculate. Length, 12–13 mm.

[1] They are described in the Bulletin of the U. S. Geological and Geographical Survey, Vol. 3, No. 2.

Front rather narrow, yellowish brown, with a ridge-like line in the middle, whose very slight expansion below represents the very narrow, almost linear, frontal callosity, which occupies less than one half of the breadth of the front; antennæ reddish; third joint rather broad, its upper corner angular, projecting; its annulate portion rather long and with very distinct divisions; palpi rather narrow at the base of the second joint, yellowish white, with short, black hairs; face white with white hairs. Thorax densely covered with whitish pollen, and clothed with recumbent white hairs. Abdomen brownish; hind margins of the segments whitish pruinose, and beset with white hairs, forming a rather broad border on each segment. Front coxæ yellowish white, with white pile; front femora, tips of tibiæ and tarsi brown; the basal three quarters of the tibiæ whitish, beset with white pile; the four posterior tibiæ likewise yellowish white, except their extreme tip, which is infuscated; posterior tarsi brownish, paler at the basis. Wings slightly grayish, unicolorous; first posterior cell broadly open.

Hab. Missouri (Say); Cumberland Gap, Ky. (George Dimmock); Georgia (H. K. Morrison); Kansas (G. F. Gaumer). Three females.

This singular species will be easily recognized, especially by the smallness of the frontal callosity. On the vertex there is a distinct tubercle, and if this is the ocellar tubercle it would be, to me at least, the first instance of its presence in a species with glabrous eyes.

Tabanus endymion n. sp.

Male. Thorax brown, whitish anteriorly, scutellum white; abdomen chestnut brown, the segments with broad white margins; fork of third vein and crossveins at the base of posterior cells (except the third), spotted with brown. Length, 15–16 mm.

Face grayish white, with white hair; palpi brown; antennæ reddish brown, third joint more reddish, with a projecting, angular upper corner. Eyes bare. Thorax of a rich, pure brown behind, slightly grayish pollinose anteriorly, where some faint vestiges of stripes are visible; humeri whitish; the ground color of the scutellum is concealed under a thick white pollen and white pile; between the scutellum and the root of the wing, on each side, a fringe or tuft of snow-white hair; pleuræ and pectus grayish pollinose, with white hairs; a large tuft of dark brown hair forms a stripe beginning at the antealar callosity and running across the pleura. Abdomen subconical, reddish brown, darker brown posteriorly, with a blackish longitudinal stripe along the middle of the first three segments; posterior margin of segments two to four white; on segments three and four the white is slightly expanded, subtriangular, in the middle; segment five has a narrow whitish border; on the venter, the corresponding segments are also bordered with white. Legs blackish brown, beset with black hair, knees and base of tibiæ slightly reddish. Wings faintly tinged with brownish, which tinge is more distinct behind the dark brown stigma; the root and the costal cell are brownish yellow; a rounded brown spot on the bifurcation of the third vein; crossveins at the base of the second, fourth and fifth posterior cells distinctly, that at the base of the first and third more faintly clouded; first posterior cell with a hardly perceptible coarctation.

The head is comparatively small, for a male, not much broader than that of the female, although distinctly more convex; the area of the larger facets is distinctly limited below, about the middle of the eye; its limit is evanescent above towards a broad border of smaller facets along the posterior orbit.

Female. Thorax grayish brown, with grayish lines; abdomen brown, posterior margins of the segments white, expanding into large triangles in the middle; fork of third vein and crossveins at the base of all posterior cells spotted with brown. Length, 16–17 mm.

Face white, with white hairs; palpi reddish, moderately stout, beset with whitish and black hairs; front brown, gray towards the vertex; callosity reddish brown, with a spindle-shaped prolongation; antennæ brownish red, third joint with an angular, well marked upper corner, the annulate portion shorter than the joint. Thorax pale brownish, grayish pollinose, with longitudinal grayish white lines and whitish hairs; a stripe of dark brown pile between the root of the wing and the humerus; pleuræ whitish, with white hairs; scutellum of the same shade of color as the thorax. Abdomen brown, hind margins of the segments white, the white borders expanding on the sides and still more in the middle, where they form large white triangles, especially on segments two to five; a white stripe in the middle of segment six; venter reddish, brownish towards the tip; posterior margins of segments white. Legs reddish brown; tibiæ more reddish at the base, femora with white pile. Wings slightly tinged with grayish brown, with a distinct bluish opalescence; the bifurcation of the third vein and the crossveins at the base of the second and third posterior cells bear large brown clouds; smaller clouds on the other crossveins; first posterior cell somewhat coarctate.

Hab. Georgia (H. K. Morrison); two males and two females.

There is a great difference in the coloring between the two sexes, especially in the thorax and the scutellum, nevertheless I do not doubt that they belong together. The male is a remarkably handsome insect; the female has a superficial resemblance to the smaller specimens of *T. Reinwardtii*, but is easily distinguished by the absence of the lateral white spots on the abdomen.

Tabanus exul n. sp.

A large number of well preserved specimens of *T. abdominalis* have enabled me to recognize the true character of this species, and to distinguish it very easily from the specimens with an open first posterior cell and broad front, mentioned at the end of my description on p. 436. The latter constitute a different species, which I call *T. exul.*

As my description of *T. abdominalis* was principally based on a small and very abnormally colored specimen, I prefer to give a description of both species.

T. abdominalis. First posterior cell closed; front narrow, frontal callosity narrow, elongated. Length 18–22 mm.

Female. Face pale yellowish gray, with pale colored hair on the cheeks; palpi black; front narrow, yellowish gray, mixed with brownish; frontal callus narrow, much longer than broad, black or dark brown; a linear prolongation above; basal joints of the antennæ very dark, and clothed with short, black pile; third joint red, rather broad, with a rectangularly projecting upper angle; annulate portion generally darker, brownish. Thorax brownish gray, with alternate gray lines and darker stripes; the former are clothed with short, golden yellow hairs. Pleuræ of a dingy yellowish gray, with hairs of the same color; a tuft of black pile in the middle, and a fringe of such pile between the humerus

and the root of the wings. Abdomen rufous; second segment with an ill-defined, black, cloud-like spot anteriorly, in the middle; similar black shades of variable extent on the following segments, so that on segments four, five and six, the anterior two thirds of the segment are often blackish brown, leaving a rufous posterior border, which is broader laterally; the black regions are clothed with short black pile, the rufous ones with reddish golden pile; a faint reddish yellow triangle is usually visible in the middle of the hind margin of the second segment; it is still less distinct, often obsolete, on the following segments. Venter uniformly yellowish rufous; the last segment with some black pile. Legs black, basal part of the tibiæ red, to a greater or lesser extent; hind tibiæ with a fringe of hairs, which is red above, black below. Wings tinged with brown, which is more saturate along the veins; a distinct brown cloud on the bifurcation of the third vein; paler clouds on the crossveins; first posterior cell closed.

Hab. Kentucky (G. Dimmock); Georgia (H. K. Morrison). Nineteen females.

The reasons which induce me to believe that this is the true *T. abdominalis* of Fabricius have been stated on p. 434.

T. exul. First posterior cell open, although strongly coarctate at the end; front (♀) broad, frontal callosity of the corresponding breadth. Length (♀) 18–22 mm.; (♂) about 20 mm.

Female. Very much resembles *T. abdominalis* in the coloring of head, thorax and wings; the palpi are dark reddish brown, densely beset with minute black hairs. The abdomen is much less rufous in coloring and has, on segments two to five, well marked, elongated yellowish white triangles, which do not quite reach the anterior margin of the segment. Other differences, which I perceive in most specimens, consist in the color of the fringe of hairs on the hind tibiæ, which is altogether black here, and not red in its upper portion; and in the antennæ, the third joint of which is a little narrower.

Male. Head subhemispherical, with a well marked dividing line between the large and small facets of the eye; general coloring more brownish, especially the abdomen; each abdominal triangle has a dark spot at its apex; the lateral margins, anteriorly, are also marked with black.

Hab. District of Columbia, Maryland, Pennsylvania, New Jersey. Twenty females and three males.

I possess a specimen of *T. abdominalis* in which the first posterior cell is very distinctly open; nevertheless the narrowness of the front and other characters help to distinguish this species. In the same way specimens of *T. exul* may perhaps occur with the first posterior cell adventitiously closed.

The synonyms from Palisot and Wiedemann most probably belong to *T. exul*. On page 436, line 3 from bottom, and on page 437, line 18 from top, read *T. exul* for *T. abdominalis*. The analytical table, on p. 428, will have to be read thus:

10. First posterior cell closed; front remarkably narrow. . . . . 6. **abdominalis** Fab.
    First posterior cell open . . . . . 10*a*.

10*a*. Head of the male subhemispherical; in the female the abdominal triangles are of moderate size . . . . . 6*a* **exul** n. sp.
    Head of the male but little different from that of the female; abdominal triangles large and broad . . . . . 7 **tectus** n. sp.

Tabanus fuscopunctatus.

(See *ante*, page 432.)

Male. The coloring is exactly like that of the female; the white abdominal spots very small; the toothlike projection on the third antennal joint very large. The head is larger than that of the female, without being very large for a male *Tabanus*. The line of division between the large and small facets is very distinct. Length, 20 mm. One specimen from Georgia (H. K. Morrison).

Tabanus longus.

(See *ante*, page 447.)

About fifty specimens (unfortunately all females), which I have now before me, enable me to improve my description. In the second line strike out the words "and connected with it." The third antennal joint in the majority of specimens is red, with the annulate portion black; in some rare specimens it is darker. In the fourth line of the description, strike out the words "although obtuse." The scutellum, in some specimens, is reddish. The abdomen is grayish brown rather than grayish black; the words "reddish on the sides, near the base," would better be struck out. On line twelve strike out the words "usually, but not always." The oblique white spots come in contact with the hind margin on the first segment only. The median abdominal line, as described by me, is visible only in very well preserved specimens; ordinarily, it appears as a line, interrupted at the incisures, rather than as a series of triangles. The brownish tinge in the costal cell is hardly apparent in most specimens, and hence the words "costal cell pale yellowish brown" are better omitted.

Tabanus Wiedemanni.

(See *ante*, page 455.)

Of this species I had a single specimen from Florida. I can compare now five other specimens, three from Georgia (H. K. Morrison) and two from Cumberland Gap, Ky. (G. Dimmock). Some of these specimens are larger, about 19 mm. long; in some the subcallus is only partially denuded, or not denuded at all; the specimens from Georgia show the remarkably broad linear prolongation of the frontal callosity, alluded to in the description; in the specimens from Cumberland Gap it is much narrower.

Tabanus rufus.

(See *ante*, page 456.)

Male. Much darker in coloring than the female, and at first glance very different in appearance.

Head, in proportion, not larger than that of the female (and, in fact, smaller, as the whole insect is of smaller size); in shape, also, it is but little different; there is very little difference in the size of the facets, and the line of division between the larger facets of the central portion of the eye and the smaller ones around and below, is not distinct (at least in dried specimens). Thorax black, with some yellowish pile, especially dense on the pleuræ. Abdomen black in the middle, dark brownish red on the sides, the latter color encroaching more or less on the former; the segments on each side are beset with some appressed minute fulvous hairs, forming narrow fringes on the red portion of the posterior margins;

a fringe of black pile on the lateral margins. Wings tinged more or less with dark brown; a cloud on the bifurcation of the third vein; first posterior cell distinctly coarctate. Legs yellow, beset with black pile; front femora darker. Length, 19 mm.

Two specimens from Georgia (H. K. Morrison).

The identity in the structure of the antennæ, in the venation and in the general coloring, differing only in intensity, sufficiently prove that this is the male of my *T. rufus*.

ERRATA IN THE PRODROME.

p. 382, line 5 and 8 from bottom, for *rubens* read *pudicus*.
p. 395, line 17 from top, for *areas* read *area*.
" " line 18 from top, for *regular* read *angular*.
p. 428, line 35, for *joint* read *point*.
p. 434, line 34, for *the character* read *this character*.
p. 439, line 21, place a comma after *brown*.
" " line 5 from bottom, for *or* read *on*.
p. 446, line 12 from bottom, place a query (?) before *Tab. marginalis*.
p. 448, line 3, for *competing in length* read *resembling*.
" " line 7, for *segments* read *segment*.
" " line 11 from bottom, for *male* read *female*.
p. 455, line 14 " " for *basal* read *posterior*.
p. 457, line 15 " " for *fulvous* read *glabrous*.
p. 459, line 14 " " for *species* read *specimens*.
p. 461, line 16 " " for *front* read *first*.
p. 469, line 22, for *more* read *none*.
p. 472, line 3 from bottom, for III read II.
p. 475, line 26, after *Pangonia seniflava* add as a synonym: *bicolor* Macquart, Dipt. Exot., 4° Suppl., p. 27, 57 (Synonymy by Bellardi).
p. 475, line 30, read *Lepidoselaga*.
p. 476, line 14, read *latefasciatus*.
" " line 21, add *Mexico* at the end of the line.
" " line 26, *apicalis* Macq. is a synonym of the preceding species, *Bigoti* Bellardi.
p. 478, first column, line 14, read *Lepidoselaga*.
" " second column, line 24, add II, 476 after (Chrysops).
p. 478, second column, line 25, strike out *crassicornis*.
p. 479, second column, first line from bottom, for *Zett*, read *Zell*.

XX. Supplementary Note on Fossil Myriapods. By Samuel H. Scudder.

Read Oct. 20, 1875.

When my paper upon these insects was published by this Society,[1] the drawings with which it was intended to accompany it were unfortunately mislaid. Having recently been found, and no further material having been discovered since they were drawn, I publish the figures for the assistance of any one endeavoring to study these very obscure remains. All the species described in the memoir referred to are illustrated here.

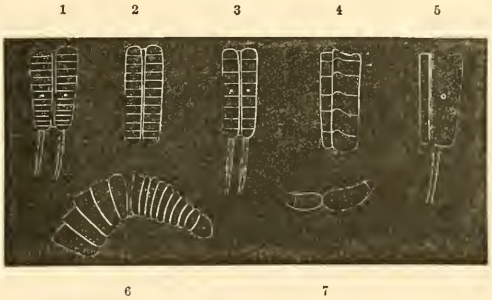


Fig. 1 represents two contiguous segments of *Xylobius sigillariæ*, showing the shape of the segments and frustra, with the position and form of the lateral pores and legs, those only of one side being shown; in this and the two subsequent figures the anterior end of the segment is at the right hand.

Fig. 2 shows corresponding segments of *Xylobius similis*, with the omission of the lateral pores and legs, these being unknown.

Fig. 3 gives the same parts of *Xylobius fractus*, with the legs and the lateral pores, the former of their supposed length.

Fig. 4 exhibits a single segment of *Xylobius Dawsoni*; here the division lines of the frustra are represented as strongly curved, only to exhibit the prominence of the anterior ridge; in this figure and the next, the anterior end of the segment is at the left hand; the slight divarication of the division lines of the frustra in this figure represents the appearance they present at the anterior extremity of the body.

Fig. 5 represents a similar segment of *Archiulus xylobioides*, showing its shape, the

[1] Memoirs, Vol. II, Part. II, p. 211, On the Carboniferous Myriapods preserved in the Sigillarian Stumps of Nova Scotia.

anterior ridge, the size and position of the lateral pores, and the length and position of the legs.

Fig. 6 is reduced from a camera sketch of *Archiulus xylobioides* to show the tapering of the anterior extremity of the body. The posterior segments of the specimen are greatly worn, and do not exhibit the anterior ridge; anteriorly the body is not very well preserved, and all the lines shown are not the division lines of segments; nor is the anterior segment a correct representation of the head; so that the figure answers only for the general outline.

Fig. 7 gives the antennal joints of *Archiulus xylobioides*, showing their close general resemblance to those of the larval antenna of recent myriapods.

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ERRATA.

p. 37, first line of note 3, for *revision* read *Division*.
p. 268, line 22, for *Gould* read *Baird*.
p. 290, line 10, for *cabinisi* read *cabanisi*.
p. 291, line 8 from bottom, for *Grayson* read *Xantus*.
p. 292, line 6 from bottom, for *Grayson* read *Xantus*.
p. 346, line 21, for *Fig.* 6 read *Fig.* 7.
p. 351, line 5 from bottom, for *Fig.* 20 read *Fig.* 22.
p. 353, in the explanation of Pl. 11, fig. 15. for *interior* read *exterior*.

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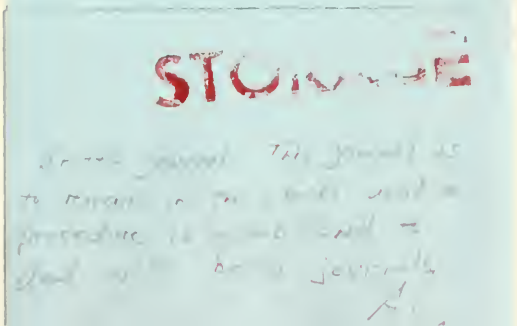
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